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JULY - 1953
Vol. 17 No. 3

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The Journal of Wildlife Management is printed by the Cayuga Press, Inc., and published by The Wildlife Society in January, April, July and October, at 113 East Green St., Ithaca, N. Y. Subscription $5.00 per year and current numbers $1.25. Society members cover subscription in annual dues. Back issues are available; volumes 1 through 8, and 13 at $8; 9 through 12, and others since 1949 at $6 per volume, $1.50 per issue.

Manuscripts for publication, books and papers for review, news notes and correspondence concerning them should be sent to the *Editor*, OLIVER H. HEWITT, Department of Conservation, Cornell University, Ithaca, N. Y.

Dues, subscriptions, changes of address, requests for missing numbers, applications for membership, and other correspondence should be sent to the *Executive Secretary*, G. A. PETRIDES, Dept. Fisheries and Wildlife, Michigan State College, East Lansing, Mich.

The Society is not responsible for supplying missing issues unless the Executive Secretary is notified within 60 days of the date of publication.

Entered as Second Class Matter, at the Post Office at Ithaca, New York, June 18, 1951, under the Act of March 3, 1879.

Articles in this Journal are indexed in the Agricultural Index, available in many libraries.

THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 17 JULY 1953 NUMBER 3

RAINBOW TROUT (*Salmo gairdneri* RICHARDSON) IN THE HAWAIIAN ISLANDS *

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and

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INTRODUCTION

Wherever white man has settled, he has invariably attempted to introduce game fishes of his homelands. Witness the introduction of various trouts in Africa, New Zealand, Australia and South America by Englishmen and of centrarchids and Pacific salmon by North Americans wherever aquatic conditions appeared suitable for successful acclimatization. While many of these attempts have failed, others have been spectacularly successful. Here we are concerned with the status of the rainbow trout, *Salmo gairdneri* Richardson, fishery on the Island of Kauai where these fish were first introduced in 1920. While this particular introduction cannot be considered spectacularly successful, the trout have done well and have developed stable, self-sustaining populations in a few of the headwater tributaries of the Weimea River.

At the request of the Territorial Board of Agriculture and Forestry, it was our privilege to study these and other island streams over the period from July 8 to September 15, 1949. The purpose was to develop a long-term stocking and management program for the expansion of trout fishing in mountain streams of the Territory. This was a unique experience for us. We had in the course of the study, some of the best trout fishing we ever encountered and in a tropical environment where the streams flow through narrow avenues of giant ferns, ginger and calla lilies flanked by forests of Koa and Lehua trees. These headwater streams were originally barren of fish life, for even the agile, climbing goby or oópu, *Awaous guamensis* (Valenciennes), was unable to surmount the high falls and cascades which clearly and ecologically separate the upper from the lower stream areas. The period from July 13 to August 20 was spent in field work on the streams of Kauai and three days, August 29 to 31, were available for inspection of the streams of Maui.

* Published with permission of the Board of Agriculture and Forestry of the Territory of Hawaii.

After the field work was completed in late August, the writers worked up the collected materials at the Marine Station of the University of Hawaii in Honolulu and these data provided the basis for the senior author's original report [1] to the Board of Agriculture and Forestry.

Further work on the field materials was completed on the Berkeley Campus of the University of California. It seems desirable to present the major findings in order that they may be made readily available to other workers and to make an official record of the field observations on both the trout and the streams they occupied as found in the summer of 1949.

METHODS

Standard methods developed by fishery biologists for the examination of streams were used. Water and air temperatures, and pH values were taken in practically all the waters examined. The pH values were determined by using a Hellige Pocket Comparator, Model 605, with four permanent, glass, color standards. These gave a range from 2.0 to 9.5. The quantitative Surber stream bottom foods net was used where feasible for taking stream foods samples but the extreme ruggedness and irregularity of the bottom areas in most cases, prevented the collection of quantitative bottom food samples. In lieu of this, qualitative samples were obtained by hand picking and by sieving and washing the foods out of gravel, algae, mosses, and from stones using a 30-mesh soil sieve and 14-mesh handscreen. Fish specimens and stomachs were preserved in 5 per cent formaldehyde and food organisms in 70 per cent alcohol. Oxygen and carbon dioxide determinations were not made as experience has indicated that these are unnecessary in the average, clear, clean, unpolluted stream. These gases are usually at satisfactory levels and seldom become limiting factors in fish production under average conditions such as were found in the streams inspected. For the same reason methyl orange and phenolphthalein alkalinities were not taken. Fish were collected by angling and netting.

The weight of trout was recorded in grams. Measurement of the fork-length and overall length was made in inches. Some forty trout were preserved from sixty collected. Weights, lengths, and scale samples were taken. The scales were soaked in water, cleaned, and mounted dry on glass slides for age and growth analyses.

[1] "A Fisheries Survey of the Streams of Kauai and Maui with Special Reference to Rainbow Trout (*Salmo gairdnerii*)", dated September 14, 1949, Honolulu, T.H., 34 pp., mimeographed.

ACKNOWLEDGMENTS

The writers wish to thank the many persons who helped in this work. Mr. Colin G. Lennox, President of the Board of Agriculture and Forestry, and Mr. Vernon Brock, Director of the Division of Fish and Game, made many necessary arrangements for field aid, equipment, and assisted materially in planning the overall work program. Our sincere thanks are also given to the following field staff members of the Board: Mr. and Mrs. Albert Duval, Mr. Joe Souza, Mr. Ben Ohai, Mr. Douglas Christian, Mr. Henry Anderson, Mr. Henry Inciong, and Mr.

Richard Souza. William S. Needham, age 12, also aided materially in the field work. In addition, much good information on fishing areas and conditions was obtained from various sportsmen, businessmen, plantation workers, and others and our thanks are due these no less than those named above. Thanks are also given to the staff members of the Zoology Department of the University of Hawaii for the loan of space for the laboratory work in the Marine Station and for aid in locating various publications and persons consulted in the preparation of our final report. The writers also wish to thank the following persons for aid in identification of the aquatic organisms collected: Dr. R. V. Chamberlain, millipedes; Dr. Milton A. Miller, isopods and gastropods; Dr. Willis W. Wirth, the torrent midge larva; Dr. Francis Drouet, algae; Dr. E. B. Bartram, aquatic moss; and Dr. Carl Shoemaker, amphipods.

HISTORY OF TROUT INTRODUCTION

Eastern brook trout, *Salvelinus fontinalis* (Mitchill) were first introduced into the Territory in 1876 (Jordan and Evermann, 1905). An additional planting of the same species was made in the Waimea River, Kauai, in 1894. Apparently, all releases of brook trout failed to survive for not a single specimen of this species was taken in the present survey or is reported as having been taken in the present or previous years.

Rainbow trout were first introduced in 1920, when 34,500 fry and 4,000 eggs were planted. Heaviest annual plants were made in 1928 when 46,000 additional eggs were imported and in 1941 when 48,000 fry were secured. In the former year the eggs were planted in the waters of Hawaii, Maui, Molokai, Oahu, and Kauai while the fry of the latter year were all planted in waters of the Kokee area on Kauai. Evidently in the period between 1928 and 1941, it was becoming evident that best results were being obtained on Kauai and all later imports were stocked in the waters of this island. No trout of any species have been planted since 1941. According to records of the Division of Fish and Game, total imports since 1920 were 146,000 rainbow eggs and fry.

Brown trout, *Salmo trutta* Linné, were imported in January of 1935 when 23,500 eyed eggs were secured and planted in the Wainiha and other streams on Kauai. Evidently these did fairly well and produced good fishing for a few years but have now disappeared. No brown trout were taken in the present survey though intensive effort was made to secure them in stream areas where they were previously reported to be plentiful. The last brown trout reported seen, a fish around 10 inches in length, was found dead in April of 1949 in the fore-bay pool of the penstocks of the Wainiha powerhouse.

Another salmonoid fish introduced into Territorial waters was the Chinook salmon, *Oncorhynchus tschawytscha* (Walbaum). Jordan and Evermann (1905) report that they were first introduced in 1876 but the numbers planted and place of planting are not recorded. Imports of this species were made each year from 1925 through 1929 by the Division of Fish and Game. A total of some 66,000 fry and eggs were imported

and planted in the Wainiha and Hanalei streams on Kauai, but failed to become established probably because of excessively warm ocean temperatures.

HEADWATER TRIBUTARIES OF THE WAIMEA RIVER

All of the main streams on Kauai have their origins high on Mt. Waialeale, the highest point on the island (elevation 5,080 feet). The annual rainfall on this mountain in 1942 was slightly over 51 feet though the average between 1930 and 1942 was 44.7 feet (537.5 inches) (Zimmerman, 1948). Rainfall in the trout areas varies from 15 to 50 or 100 inches depending upon proximity to Mt. Waialeale. In general it may be said that rainbow trout prosper and are well established only in Kokee and Kauaikinana streams at elevations between 3,000 and 4,000 feet on the northwestern segment of the island. These headwater tributaries of the Waimea River flow out of Alakai Swamp, a broad upland plateau cut by numerous sub-drainages (Fig. 1).

Rainbows from Kokee and Kauaikinana streams are beautifully marked, red-sided, and in general appearance are somewhat darker than the usual continental forms. Parr marks, so characteristic of 4-to 5-inch fish were still evident in adults 11 and 12 inches in length.

Kokee stream between the Ranger Station and the Kokee diversion dam contained by far the greatest population of rainbow of any stream examined by us. Fish were abundant and as many as 25 to 30, ranging from four to eighteen inches could be seen in many of the pools. This three-mile stretch of stream is almost impossible to fish because of the dense beds of ginger that line its banks at many places and it was surveyed only by wading or swimming.

Other headwater tributaries of the Waimea River which had been stocked in earlier years with rainbows but which were found barren of trout in 1949, were the Kauaikoi, Mohihi, Koaie, and Waialae streams (Fig. 1). No other fishes occupy the headwaters of these streams though the native Hawaiian climbing goby is common below the palis (falls) in the middle and lower stream areas and are caught in large numbers for food. While trout have been reported to be present below the palis, it is extremely doubtful that either trout or their eggs could survive the tremendous drop of several thousand feet into the exceedingly rough, boulder-strewn cascades of the lower canyons.

The water of streams draining Alakai Swamp is a deep brown in color typical of bog waters that contain much tannic acid from decomposing plant remains. The pH values further confirmed their high acidity giving values as low as 5.3 (Table 1).

In the summer during the dry season, most of the water from the Kokee, Kauaikinana, and Kauaikoi streams is picked up by low diversion dams (Fig. 2) above the palis and diverted via an extensive ditch and tunnel system into Puua Lua Reservoir near Puu Ka Pele Lookout on the west side of Waimea Canyon. From there it is passed through other ditches and distributed for irrigating sugar cane fields that cover the lower southwest slopes of the island.

Rainbow trout have drifted downstream and are found throughout the entire upper waters of this system. In

TABLE 1.—WATER TEMPERATURES, pH VALUES, FISHES PRESENT AND OTHER CONDITIONS FOUND IN HEADWATER STREAMS OF KOKEE AREA, KAUAI, T. H. IN 1949

TABLE 1.—WATER TEMPERATURES, pH VALUES, FISHES PRESENT AND OTHER CONDITIONS FOUND IN HEADWATER STREAMS OF KOKEE AREA, KAUAI, T. H. IN 1949

STREAM, STATION AND DATE	TEMPERATURES			pH	DOMINANT FOODS[1]	FISHES PRESENT	REMARKS
	AIR	WATER	TIME				
Kokee Stream below pumphouse dam, July 18.	72° F	60° F	10:10 AM	6.8	Midge larvae, millipedes, angleworms. Food poor.	Only rainbow trout.	Fine spawning gravel in spots among boulders. Large trout seen below YWCA Camp. Excellent brood stream.
Kokee Stream above Diversion Dam below Hale Manu, July 20.	74° F	64° F	11:00 AM	6.8	Same as above but richer than Kokee at Pumphouse station.	Only rainbow trout.	Stream-side crowded by ginger. Excellent spawning shelter and spawning conditions.
Ditch between Kauaikinana and Kokee Diversion Dam, July 28.	73° F	63° F	5:30 PM	5.9	Midge larvae, red shrimp, millipedes, angleworms, and damselfly nymphs.	Only rainbow trout.	Ditch contains water from Kauaikinana, Kawaikoi, and Waiakoali Streams. Fairly good trout population here.
Ditch 3 miles below Puu Ka Pele Lookout near warehouse and road, July 28.	75° F	64° F	9:30 AM	5.3	Red shrimp, isopods, midge larvae, angleworms, millipedes. Food abundant.	Only rainbow trout.	Good trout population here; water brown; rotary fish screen below would prevent loss of trout in canefields.
Ditch 8 miles below Puu Ka Pele Lookout along road just above canefields, July 28.	78° F	66° F	10:10 AM	5.3	Food very poor because of intermittent flow at this point.	None	Rotary fish screen should be placed above this point where permanent water is maintained in the main ditch.
Kauaikinana at road crossing above Kokee, July 19.	77° F	65° F	10:37 AM	6.7	Food only fair; midge larvae and damselfly nymphs dominant.	Only rainbow trout.	Subject to severe freshets. Fish ladder where ditch dumps into this stream would aid upstream spawning migrations to Kauaikoi and Waiakoali.
Kauaikoi at road crossing above Kokee, July 21.	68° F	65° F	10:30 AM	5.9	Food tremendously abundant. Took 127 damselfly nymphs from 120 sq. inches of moss[2] on surface of rock. Midge larvae also very abundant.	No trout collected and none seen. No other fish present.	Brown water, subject to severe floods. Fine pools, riffles, shelter and natural spawning conditions. Should be restocked with eyed eggs or fry when suitable stock is available.
Waiakoali at road crossing, July 21.	70° F	66° F	11:30 AM	6.1	Food only fair. Midges, millipedes, damselfly nymphs and angleworms.	No small trout. Many large rainbows seen above Diversion Dam.	Subject to severe freshets. Good spawning and shelter conditions. Brown water.
Unnamed trib. of Kauaikinana near Joe Souza's cabin, July 20.	64° F	59° F	9:30 AM	6.5	Food poor. Midge larvae and millipedes present.	Souza reports seeing young 2"–4" trout here but none seen in present survey.	Low water temperatures of colder tribs such as this one do much to maintain low temperatures in the main streams.
Mohihi below trail crossing, July 25.	68° F	66° F	3:00 PM	6.2	Much food in moss[2] on rocks. Damselfly and dragonfly nymphs very abundant.	Big trout seen 2 yrs. ago by U.S.G.S. gaging station. None seen or caught this date (July 25).	A beautiful stream with fine pools, riffles and shelter. Subject to severe floods. Should be restocked eventually. Predation by Odonata nymphs may be the reason for the absence of trout.
Waialae Stream at Board's Camp, Aug. 2.	70° F	64° F	5:00 PM	5.9	Food abundant: Midge larvae, damselfly nymphs, and millipedes.	No trout seen or collected.	Fine, brown water stream with excellent pools, riffles, and shelter. Should be restocked. Rainbow trout formerly abundant.

[1] The identification of the various foods was as follows:
Terrestrial millipedes—*Oxidus gracilis* (Koch)
Terrestrial red shrimp—*Talitrus sylvaticus* Haswell.
Terrestrial isopods—*Philoscia* sp. were dominant; only one *Porcellio* was found in the stomachs.
Dragonfly nymphs—*Anax strenuus* Hagen
Damselfly nymphs—Probably *Megalagrion kauaiense* (Perkins).
Midge larvae—Mostly small forms such as *Chironomus* and *Tanytarsus*. The large torrent-dwelling *Telmatogeton hirtus* (Wirth) was not found by us in these headwater streams but was exceedingly abundant below the palis at lower elevations.

[2] Aquatic Moss—*Limbella tricostata* (Sullivant) C.M.

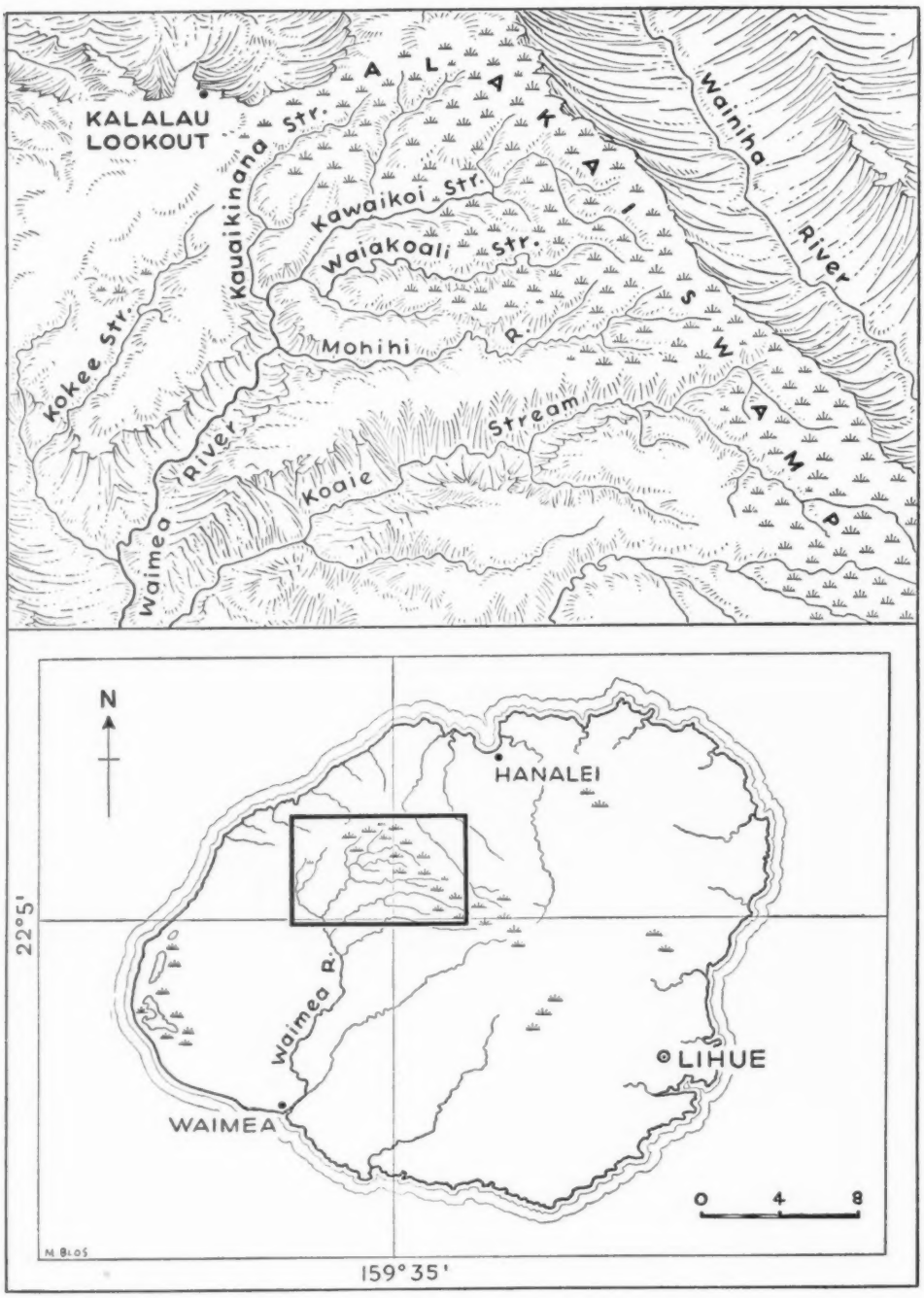

FIG. 1. Principle trout waters of the Island of Kauai, T. H. Rectangle indicates position of the large scale map above.

fact some of the best angling is afforded in the main ditch that draws water from Pua Lua Reservoir. In two hours time the junior author caught 18 rainbows and had 72 strikes while fishing this area in August of 1949. The ditches are quite fishable and produce many big trout. Many more fish are taken from the ditches than from the streams above points of diversion for the simple reason that the banks of the ditches are kept clear of vegetation and afford easy walking and angling where the streams above are practically unfishable by reason of rough terrain and dense streamside vegetation.

Pua Lua Reservoir serves as a holding pond for trout that drift downstream into it from the upper ditches and are passed into the lower ditches via an outlet tunnel. Many large trout were removed from the outlet tunnel eight or nine years ago when water was shut off for repairs. Anglers informed us that many good catches are often made by rod and line in the reservoir. Evidently fish are drifting down from natural spawning in the upper waters. Once trout have drifted downstream into this reservoir or below it, there is no possible chance of them migrating back upstream for spawning because of two impassable barriers; the outlet tunnel from the reservoir and an impassable falls where the water enters the reservoir. Since no evidence was obtained of successful, natural propagation in the reservoir or below it, consideration should be given to limiting the angling in the upper waters to protect spawning stocks and concentrating the angling on the lower ditch systems.

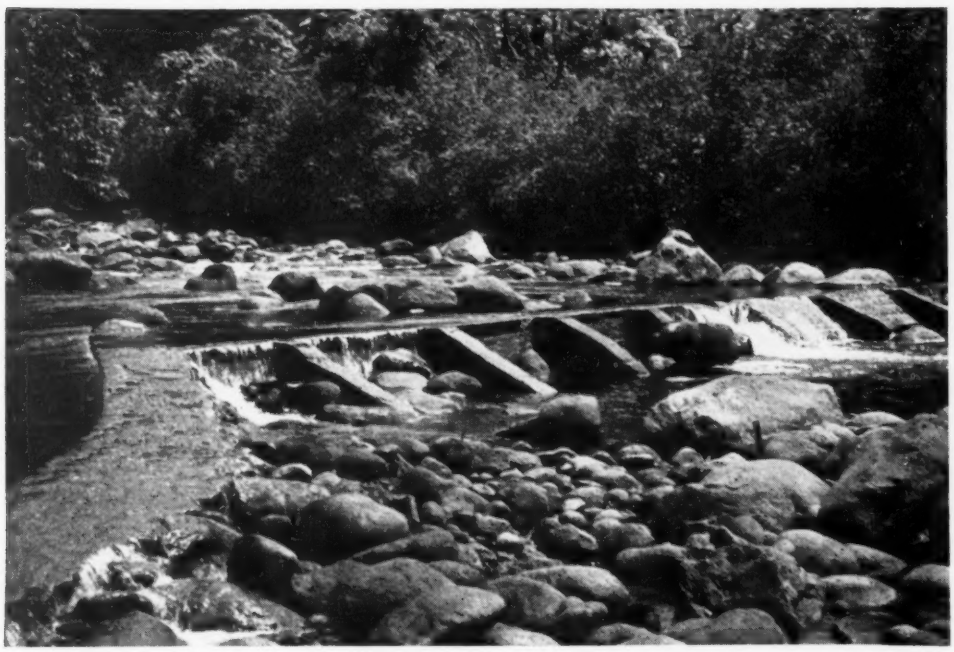

FIG. 2. Power diversion dam on Wainiha River, near Hanalei, Kauai, T. H. The water is drawn off into a ditch, one wall of which may be seen at the lower left.

FOOD

None of the typical swift-water-dwelling, immature stages of stoneflies (*Plecoptera*), mayflies (*Ephemeroptera*), or caddiceflies (*Tricoptera*) occur in island streams. On Kauai the main aquatic foods are midge larvae and pupae (*Chironomidae*) and dragonfly and damselfly nymphs (*Odonata*). Stomach examinations reported later clearly indicated that much food is furnished by terrestrial shrimp, isopods, angleworms and millipedes. In one instance (Table 1) 127 damselfly nymphs (*Megalagrion*) were picked from 120 square inches of moss in Kauaikoi Stream. In Mohihi Stream, dragonfly nymphs were enormously abundant and may well account for the absence of trout in this stream where they were formerly abundant. Nymphs of *Anax strenuus* Hagen were quite common and these large forms would doubtless find young trout fingerlings easy to capture and eat. We observed one nymph with its jaws hooked into a frog well over an inch in length.

FOODS EATEN BY RAINBOW TROUT IN KOKEE AREA

Table 2 presents the foods found in the stomachs of rainbow trout caught on Kauai. Since the foods eaten in the ditch below Puu Ka Pele Lookout vary considerably from those eaten by trout in the ditch below Hale Manu and from upper Kokee Stream, Table 2 lists the foods eaten from each of these three separate areas.

It will be noted that the red shrimp, *Talitus sylvaticus* Haswell, formed over 64 per cent of the total number of food items taken by fish in the ditch below Puu Ka Pele Lookout. These terrestrial amphipods live among damp vegetation along the edges of streams and being active at night, many jump into the water accidently where they become food of trout.

No red shrimp were found in the stomachs of fish from upper Kokee Stream. Isopods were very important in the lower ditches forming almost 15 per cent of the total number of items eaten by fish from that area. No isopods were found in the stomachs of fish taken below Hale Manu or in the upper Kokee waters.

Angleworms and millipedes, *Oxidus gracilis* (Koch), were likewise very important items in the diet of the fish examined. While comparatively few angleworms were found per stomach, they averaged 36.4 per cent by volume of the food of fish taken from upper Kokee waters. Likewise, they formed 12.4 per cent of the total number of food items found in the stomachs of fish from this region. Millipedes were important both in numbers and volume for they formed 74 per cent, 34 per cent, and 5.9 per cent, respectively of the numbers of items eaten by fish taken below Hale Manu, in upper Kokee, and in the Puu Ka Pele ditch. By volume, they bulk larger than any other single item, forming over 84.5 per cent in the case of Hale Manu fish, 17.4 per cent of upper Kokee fish, and 12.2 per cent of the foods from fish in the lower ditch.

In summary, the dominant fish foods of the ditch below Puu Ka Pele Lookout were red shrimp, isopods, angleworms, and millipedes. All of these foods are terrestrial in origin and formed over 88 per cent of the total number of items eaten. Fish from the

ditch below Hale Manu also subsisted largely on terrestrial millipedes and red shrimp. Upper Kokee fish, on the other hand, were dependent principally on terrestrial angleworms and millipedes and aquatic damselfly nymphs. Thus we find the unique situation of trout being largely dependent upon foods supplied from the land rather than from the water. The principal difference

TABLE 2.—SUMMARY OF FOODS EATEN BY KAUAI RAINBOW TROUT *

FOOD GROUP	AVERAGE NUMBER EATEN PER FISH			PER CENT OF TOTAL NUMBER OF FOOD ANIMALS			ESTIMATED AVERAGE PER CENT BY VOLUME PER FISH		
	Hale Manu	Kokee Stream	Lower Ditch	Hale Manu	Kokee Stream	Lower Ditch	Hale Manu	Kokee Stream	Lower Ditch
Terrestrial, Red Shrimp (*Talitrus*) ..	2.0	0.0	55.8	9.6	0.0	64.7	2.1	0.0	43.5
Terr. Isopods (*Philoscia*).....	0.0	0.0	12.7	0.0	0.0	14.7	0.0	0.0	3.4
Terr. Angleworms .	0.6	1.9	1.2	3.1	12.4	1.3	1.9	36.4	8.2
Midge Larvae.....	0.1	0.0	1.8	0.6	0.0	2.1	0.1	0.0	0.5
True Flies.....	0.1	1.0	2.1	0.6	6.6	2.4	0.2	0.5	1.9
Beetle Larvae.....	0.5	0.1	1.4	2.4	0.8	1.6	0.4	0.1	1.6
Damselfly Nymphs (*Megalagrion*).....	1.0	5.2	0.0	4.9	33.8	0.0	4.0	18.1	0.0
True Bugs.....	0.5	0.1	0.9	2.4	0.8	1.1	0.5	0.3	0.4
Moth Larvae.....	0.3	1.3	2.0	1.2	8.3	2.4	1.9	6.8	3.5
Terr. Millipedes....	15.4	5.3	5.1	74.1	34.7	5.9	84.5	17.4	12.2
Terr. Centipedes ...	0.0	0.0	0.5	0.0	0.0	0.6	0.0	0.0	0.3
Terr. Ants, Bees, Wasps.....	0.0	0.0	1.2	0.0	0.0	1.5	0.0	0.0	3.3
Snails.....	0.1	0.1	0.3	0.6	0.8	0.3	0.4	0.3	3.9
Algae.....	—	—	—	—	—	—	3.4	11.5	10.7
Miscellaneous ** ...	0.1	0.2	1.2	0.6	1.8	1.4	2.6	8.6	6.6

* Based on stomachs from 29 rainbow trout ranging in size from 3-7/8″ – 16-1/2″ overall length; 8 from Hale Manu, 8 from Kokee and 13 from Lower Ditch.

** Misc. includes: 1) Parts of termites, 2) Earwig, 3) Unidentified large invertebrate animal, 4) spiders, 5) seeds, vegetable matter other than algae.

between the upper and lower areas was that streams above Kokee lacked the red shrimp and isopods originating in the lower areas on the borders of the rain forest below Kokee.

Practically all the stomachs opened contained some green algae. In the upper areas above the palis, the dominant form was the filamentous alga, *Stigeoclonium tenue* (Agardh) (Kütz). Algae are commonly found in rainbow trout which are the only trout known to consistently eat them. Most of the stomachs contained small amounts but occasionally large masses were found in the stomachs.

Scale Counts

Counts of the number of scales in the lateral line of Kauai rainbows gave an average of 132 rows and ranged from 129 to 141 in six specimens counted. In this respect they fall inside the middle range of counts of the California coast rainbow which run from 120 to 150 rows as reported by Snyder (1933). We were informed in Hawaii that the original stock of rainbow trout introduced into the islands was secured from Diamond Lake, Oregon. This lake was originally barren of trout and was first stocked with rainbow taken from Spencer Creek, a tributary of the upper Klamath River near Keno, Oregon. This stream contained coast rainbows as defined by Snyder (*op. cit.*) and it is not surprising therefore to find that the scale counts fall well within the range of this species.

Age of Kauai Trout

From scale readings, it was determined that the bulk of the angler-caught fish from the Kokee area in 1949 were in their third year of life. Four-and five-year-old fish were relatively scarce. Comparatively few fish hatched the previous spring were found. Only four specimens below 5 inches in length were taken. These fish were obviously hatched in the winter of 1948-1949. Severe freshets in February, 1949 may have accounted for their absence in the summer of 1949.

Fish in their second year were from 5 to 9 inches in length. Fish in the third year ran from approximately 7.5 inches to 10.5 inches in length; those in their fourth year from 10.5 inches to around 14 inches, while five-year-old fish were 15 inches and larger. Ages were determined from scale readings on 32 fish.

Length-Weight Relationship

The relationship of length to weight is presented in Figure 3, as a power curve representing the calculated weight values of trout at any given length interval.[2] The exponential equation of the curve is given as $Y = 6.052\ (1.1403)^x$ where Y equals weight of trout in grams and X equals fork length of trout in centimeters.

Proportion of Males to Females

In a sample of 58 trout collected, 14 were males and 40 were females. Sex could not be determined in 4 of the fish. Finding a sex ratio of almost 3 females (2.8) to one male is most unusual and the χ^2 test (Snedecor, 1946) was used to test its significance. As-

[2] The exponential equation $Y = ab^x$ was used to express the direct length-weight relationship of Kauai trout because log Y plotted against X yielded the best straight line for that part of the length-weight curve covered by most of our measurements.

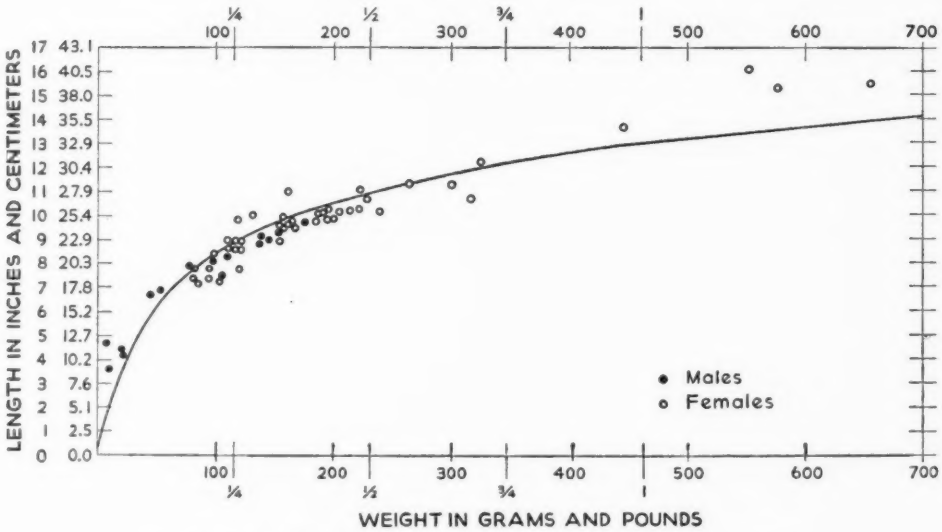

FIG. 3. Weight-length curve of rainbow trout taken on Kauai, 1949.

suming the extreme possibility that all 4 trout of undetermined sex were males, tests for the significance of a sex ratio of 14 plus 4 males to 40 females gave a probability value which indicated that there was a slightly more than a 100 to one chance that the deviation was due to chance in sampling (adjusted $\chi^2 = 7.6$).

It is likely, in view of these findings, that fertilization of the eggs is accomplished by two-and three-year-old males. Examination of the scales indicated most of the males were in their third year of life. A number of females secured were 4 and 5 years old. It should be remembered that most of the fish taken were angler-caught and this group may not necessarily represent the normal stream population. Recourse to poisoning of the streams or ditches to get a more complete sample was not taken because of the heavy kill that would have taken place in the restricted environment available to them on Kauai.

It will be seen in Figure 3 that no male fish larger than 9-5/8 inches were taken. All fish above this size were females. The proportion of males to females under 9 inches ran approximately 13 to 16. While the former condition is unique, the latter situation is not outside the limits that one would expect to find in any normal population. Males of many salmonids often mature sexually before the females, spawning usually either one, two, or three years before females of the same brood year. Possibly in the streams of Kauai, early spawning of the males plus the hardships incidental to spawning in the somewhat high temperatures, might cause an excessive mortality in male fish. This is the first case in which the writers have ever found such an imbalance between sexes in trout and further studies should be continued to determine the cause.

NATURAL SPAWNING

Clear, definite evidence of successful,

natural spawning by trout in the Kokee area was found from careful examination of the gonads of female rainbow. Three females taken had spawned previously. One specimen would have spawned in the winter of 1949-50 as the eggs were close to maturity in the body cavity. In another female, thirty-seven eggs were found being resorbed in the body cavity following spawning in the winter of 1948-49 and new eggs were developing for spawning in the winter of 1950-51. Two others had a considerable number of eggs remaining from previous spawnings. This is not an uncommon condition for it is impossible for the females to completely spawn out all eggs during breeding activities. Previous work on this problem has indicated that from 5 to 8 per cent of the total number of eggs contained in any given fish may remain in the body cavity following completion of spawning (Needham, 1938).

OVARIAN EGG COUNTS

Counts were made of the number of eggs in the ovaries of nine maiden rainbow trout taken from Kokee Stream and the ditches below Hale Manu and Puu Ka Pele Lookout. These fish varied from 7.2 inches to 12.2 inches in length from the tip of the snout to the center of the fork of the tail. Their average length was 9.9 inches.

The average number of eggs found per female was 1129. The counts ranged from a low of 482 to a high of 1332 and thus were well within the expected range for maiden rainbow trout. While both three-and four-year-old fish were represented, most of them would have spawned for the first time at the end of their fourth year of life.

MALFORMED REPRODUCTIVE ORGANS

Out of 61 specimens, five males and four females gave indications of having malformed testes or ovaries. The testes of the male fish instead of being a translucent white as is normal, had dark or grey external blotches and appeared to be atrophied or reduced in size. Similarly, the ovaries in some cases were much darker than normal and contained eggs which were very uneven in size. In two instances, new eggs developing in females that had spawned before looked dark and atrophied and likely would not have produced healthy eggs during later spawnings.

Examination of histological sections of both normal and abnormal ovaries were made. These indicated an arrested state of development in the latter. In many instances the nuclei of the ova appeared to be disintegrating and merging with the surrounding cytoplasm. All of the ova in the abnormal ovary were quite immature and the connective tissues, smooth muscle fibers, and blood vessels were much less abundant than in the ovary that appeared to be normal on gross examination. Small ova were abundant in the normal ovary but were very scarce in the abnormal. The most striking difference between the two was that in the normal ovary the yolk possessed large numbers of homogenous spherules which stained deeply while in the abnormal there were very few of these spherules or they were absent entirely. The few that were present stained only faintly and were usually more or less granular instead of homogenous. It is doubtful if any of these ova would have developed further. Close examination of sections of the normal ovary indicated that it could

hardly be called "normal" since it too contained some ova very similar to those observed in the abnormal gonad and there were frequently instances where apparently nearly mature ova had collapsed and only their envelopes remained.

Many of the testes removed from trout taken in the lower ditches appeared abnormal being grayish in color in contrast to the glistening white appearance of normal testes. Testes of males taken from upper Kokee stream on the other hand usually were normal in appearance. Histological examinations of both types indicated large numbers of degenerating cells in the abnormal appearing testes that were not present in the others.

There was no evidence of disease or parasites to explain the conditions observed in the sections, and it is our belief the high water temperatures may well be the cause.

Embody (1934) reports that eastern brook and brown trout eggs require water between 37.4° F and 50° F for normal development and hatching, and concluded that the norm for the proper incubation of rainbow eggs after spawning was located approximately between 48° F and 60° F. His experiments dealt wholly with the relation of temperature to incubation periods. In the case of the Kauai rainbow, high losses could occur after spawning because of excessively high temperatures, but it seems more likely that their failure to reproduce in many waters may lie in the severe atrophy of the sex products because of high temperatures in the winter when they are ripening in preparation for spawning. The problem obviously is of a physiological-ecological nature involving marginal reproductive conditions. Experimental rearing of rainbows in water temperatures ranging from 55° F to 60° F would provide the material for a thorough study of the problem. The senior author has reared rainbow trout to breeding age in 61° F spring water and found the eggs were a total loss. Other rainbow from the same strain of fish held in 56° F spring water to breeding age produced normal, healthy eggs. The critical temperature area thus apparently lies between 55° F and 60° F. It has been the experience all over the world that if water temperatures run over 60° F. for long periods of time, the eggs produced are likely to be of poor quality and give low survivals. This is a frequent complaint where attempts have been made to establish rainbow trout in the tropics. It is claimed that in Kenya Colony, Africa, the rainbows do very well in the streams as far as the growth and physical condition of the fish are concerned, but the great majority of the females are unable to spawn and in many of those that do, very few eggs hatch.

Apparently 1946 was a year of fairly successful natural spawning in Kokee Stream for the great bulk of fish taken was of the 1946 brood year. The winter season of 1948-49 was less successful from a spawning standpoint for very few young fish of the year were observed. The cause for serious reduction of the zero age group in 1949 could have been floods rather than temperatures for we received many reports of small trout being numerous in February of 1949.

WINTER WATER TEMPERATURES

Winter water temperatures in 1946 in

Kokee Stream are plotted in Figure 4. Here it is indicated that a period of approximately four months occurred when the water temperatures ran below 56° F., and they were below 60° F for six months of 1946. It is evident that streams of the Kokee area are the only ones on Kauai in which suitable temperatures exist for natural reproduction of trout but even there they are close to the margin of safety.

As was stated earlier, the lower waters of Poomau, Koaie, Mohihi and Waialae streams below the palis are all suitable so far as the growth of trout is concerned, but it is our opinion that rainbow trout will never reproduce successfully in these lower waters even though the temperature during the winter may at times drop below 60° F. If it is desirable to create rainbow fishing in these waters or in waters of the Hanalei area, or on Maui, it will mean frequent stocking of eyed eggs or young fry to keep young stocks coming on to replace those caught by anglers or removed by predation and competition.

As was indicated earlier here, evidence of successful brown trout spawning was obtained in the upper Wainiha River in past years by sportsmen fishing the area. These were apparently limited to the headwaters of the stream and the young produced probably resulted from one favorable winter season of low water temperatures for natural spawning. Since brown trout were stocked only in 1935 the numerous young fish seen in the early forties could have resulted only from natural propagation.

LOWER SECTION OF WAIMEA RIVER

Two pack trips were made into the rugged Waimea Canyon below the palis. A considerable amount of time was devoted to inspection of these

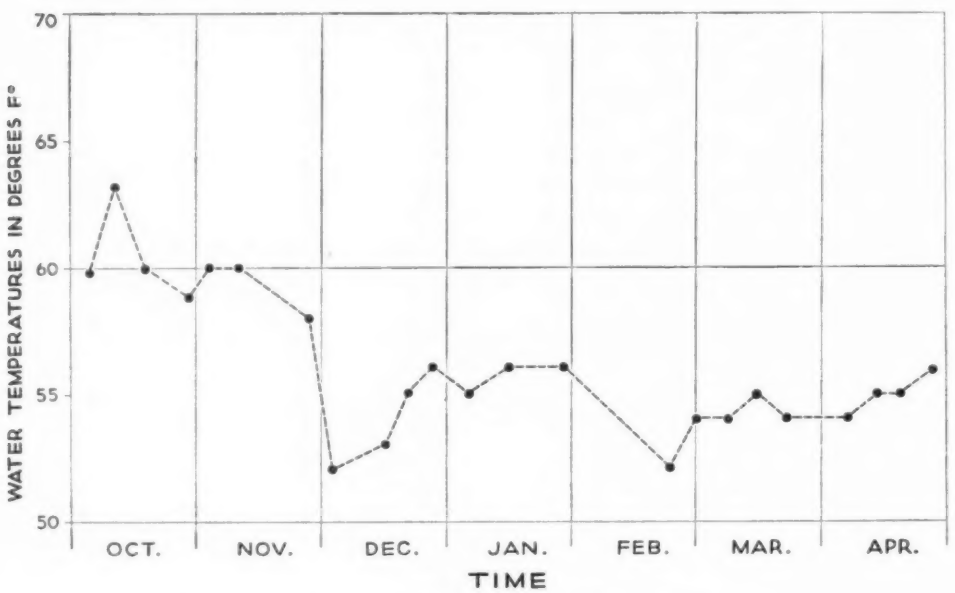

FIG. 4. Winter water temperatures in 1946 in Kokee Stream.

waters that originate in Alakai Swamp in an effort to determine whether or not trout had successfully navigated the falls over the palis and become established in the lower waters.

It is not improbable to suppose that trout might have come over the falls into the Waiahulu as well as the Poomau, Koaie, Mohihi, and Waialae streams. While spawning temperatures are unsuitable in these mid-stream areas, if they had survived their trip over the falls they should have been found present. A large rainbow trout was reported to have been seen in the lower Koaie above our camp but heavy fishing did not reveal a single fish. As was noted above, because of the ruggedness of the country and many steep falls and cascades, any trout that drift or are swept over the falls are probably killed.

The only fish present were the oópu or goby mentioned above and they were quite abundant in both the main Waimea and all tributaries examined in the mid-canyon areas. To illustrate the ability of these fish to climb sheer falls, we found them dwelling quite happily above a sheer, 70 foot fall on the upper Poomau and they certainly could have gotten there only by passing over this fall under their own power. They seem to reach greatest abundance in stream sections having deep pools, rapids, and falls. Just how far up the many falls over the palis they have been able to migrate has not been determined. We ran out of trails and even on foot the going is extremely rough and at times, dangerous.

Oópu are catadromous and when mature, migrate downstream to estuarine areas where they spawn. The young (hinana) in turn, migrate back upstream. Even if oópu were swept downstream by heavy floods, their fused ventral fins which form a sucking disk plus use of their wide ventral mouths would permit them to climb back upstream. Hawaiians trap them in large numbers for food when they are moving downstream to spawn in late summer on the first freshets of the rainy season. Considerable numbers are also caught by hand under stones in the dry seasons below the diversion dams.

WATER TEMPERATURES IN WAIMEA CANYON

Water temperatures suitable for growth of rainbow trout were found in all sections and tributaries examined but not a single trout was seen or caught by any member of our party. Besides the main Waimea River the following tributaries were examined and foods, temperatures, and other data recorded from them: Upper Poomau, Waialae, Koaie, and Waiahulu streams. No water temperatures of over 78° F were found in the mid-canyon areas of the Waimea River at elevations of from 1,000 to 1,500 ft. and they ran roughly 8° F to 11° F higher than their headwaters in Alakai Swamp some 2,500 feet higher.

Diurnal fluctuations in water temperatures in the mid-canyon areas usually ran around 4° F to 5° F, as indicated by readings taken at 6:00 A.M. and 6:00 P.M. in August.

Water is diverted for both power and irrigation in main Waimea canyon. In the summer dry season this usually causes stagnant water conditions below the dams. On August 4, we found the main Waimea stagnant and warm

(78° F) below the diversion dam of the Kekaha Ditch. However there was enough seepage water and water from untapped tributaries to maintain a flow sufficient to keep oópu alive but for trout, conditions were decidedly unattractive.

The pH of the water in the lower Waimea Canyon was 8.5 on August 20 at 3:00 P.M. Whereas acid conditions were found in the upper tributaries of the Waimea, alkaline conditions were found generally in the seepage water remaining in the river bed below the dams. Diversion of the more acid waters coming from Alakai Swamp into the irrigation and power ditches above might explain the difference in pH values between the lower and upper waters.

TORRENT MIDGES

While somewhat similar fish food organisms of the Waimea River were found in both the upper and lower waters, there was one major difference. Torrent midge larvae *Telmatogeton hirtus* (Wirth), were seen by the thousands in their white, silken cases fastened to the upper surfaces of stones and boulders in swift, shallow water in the mid-canyon areas. These were entirely absent from our collections in the upper waters.

These are remarkable larvae. When full grown they are about an inch in length and are by far, the largest midge larvae we have ever seen. They furnish a rich source of food for the oópu. Just how these larvae which live in the most exposed situations on the tops of rocks and boulders in shallow water are able to survive the destructive effects of flood-borne rocks, sand or other debris is a mystery. Dr. Willis W. Wirth in a personal communication to the senior author of February 9, 1950, said, "I believe that *hirtus* is the most highly evolved of the Hawaiian species, with a series of existing species on various islands and mountain ranges with progressively more specialized characters leading to it. The larvae, and particularly the pupae, can withstand tremendous beatings and pressure from torrential stream conditions, within their silken cases on the rocks. I have observed the coastal, intertidal species breeding on the most exposed rocky coasts; in fact they seem to prefer such places where the surf is very strong. On the coasts the waves exert tremendous pressure, but as a rule *Telmatogeton* are not found where loose boulders or stones can grind them. In addition I believe they nearly always colonize where their silken tunnels can extend back into tiny fissures, although many pupae are found immobile on smooth rock faces. There are many interesting and unsolved problems in the biology of these midges which should prove fascinating for someone who likes to study with the music of roaring water in his ears."

STREAMS NEAR HANALEI

The streams near Hanalei on the northeast sector of Kauai are much larger in terms of volume of flow than streams draining to the south and west from Mt. Waialeale (Table 3). These streams lie in the belt of heavy precipitation and less water is diverted from them for irrigation than from streams on other parts of the island. Details from the survey of these waters are presented in Table 3. These are a magni-

ficent group of streams, especially the Hanalei, Lumahai, and Wainiha, and would compare favorably with such famous mainland streams as the Ausable River in New York State, the Merced River in California or the Metolius River in Oregon. Oópu were the only fish found, though brown trout were once abundant in the Wainiha (Table 3).

One of the most characteristic features of the lower portion of the streams near Hanalei was the great abundance of the alga, *Lyngbya putealis* Gom. Everywhere in shallow, moderately swift water, this coated the stones with a light green scum.

Temperatures suitable for growth of trout existed throughout their courses above the estuaries but may be too high for successful natural spawning. Rainbow from Kokee Stream might reproduce successfully in the Wainiha. Splendid trout fishing could probably be had by occasional plants of eyed eggs or fingerlings. Lying close to the famous Hanalei Beach, one of the major tourist attractions in the islands, good trout fishing there would provide an unusual, recreational asset in a wholly tropical setting.

STREAMS OF MAUI

Lacking a water storage area like Kauai's Alakai Swamp, Maui streams are largely fed by run off waters from heavy precipitation at high elevations (Table 4). Much the same fish foods occur here as on Kauai. Water temperatures ran somewhat warmer than in the Kokee area and for this reason it is doubtful that any of them are suitable for trout reproduction. The same temperature blocks to natural propagation occur here as occur in all of the middle and lower courses of the streams on Kauai. Nonetheless, temperatures were still suitable for the growth of trout even at their lower ends just above tidewater. Temperatures above the optimum range for trout were found only in the estuarine areas subject to influx of tidal waters from the ocean. This can be said to apply generally to all streams examined by us. Here too, occasional plantings of eyed eggs or young fingerlings might produce excellent fishing.

While streams of both islands present extremely rough, boulder-strewn beds, largely not accessible to anglers, streams on the north coast of Maui between Pauwela and Kaeleku are extreme in this respect. The waters falling through steep volcanic crevices present one sheer fall after another over most of their courses.

INTRODUCTION OF STONEFLIES, MAYFLIES AND CADDICEFLIES

To provide a buffer food supply for odonatan nymphs and in turn to reduce predation by these forms on young, naturally spawned trout, it would be desirable to introduce lotic forms of stoneflies, mayflies and caddiceflies into island streams. Aside from midge larvae, millipedes, and young frogs, dragonfly and damselfly nymphs have but little to feed on and if more normal stream faunas were present, certainly pressure on young trout would be reduced considerably. While odonatan nymphs are eaten occasionally by larger trout, their predation on young trout, more than counterbalances their value as trout food.

A third reason for such introduction stems from the side of angling. Fly hatches would be produced that create

TABLE 3.—WATER TEMPERATURES, pH VALUES, FISHES PRESENT, FOOD AND OTHER CONDITIONS FOUND IN STREAMS NEAR HANALEI, KAUAI, T. H. IN AUGUST, 1949

STREAM, STATION AND DATE	TEMPERATURES in ° F			pH	DOMINANT FOODS[1]	FISHES[2] PRESENT	REMARKS
	AIR	WATER	TIME				
Wainiha River just above tailrace of the powerhouse. August 13.	80°	71°	10:30 AM	6.8	Opae, torrent midge larvae, damselfly nymphs; food poor at this station.	Only oópu.	Bottom stones heavily coated with algae,[4] rugged; many fast riffles and deep pools. Too warm here for trout reproduction.
Wainiha River just above intake ditch to P.H. on main stream, Aug. 14.	80°	67.5° 69.5°	11:15 AM 2:00 PM	6.9	Opae, torrent midges and damselfly nymphs. Food abundant.	Only oópu.	Brown trout used to be common here but have apparently disappeared now. Beautiful, fine white water stream. Trout might be able to reproduce in the colder headwaters.
Lumahai Stream at end of road 4½ miles from ocean, August 16.	83°	70°	11:00 AM	7.3	Opae, gastropod molluscs,[3] torrent and other midge larvae; food only fair.	Only oópu.	Bottom stones heavily coated with algae;[4] signs of heavy freshets; large pools and riffles; too warm for trout reproduction.
Waipa Stream near mouth, Aug. 13.	80°	78°	2:00 PM	6.9	Opae, midges, damselfly nymphs; food mediocre.	Only oópu.	Too short, small and warm to consider for trout.
Waioli Stream August 13.	81°	76°	3:00 PM	6.9	Same as Waipa, poor.	Only oópu.	Flow small, too short and warm to consider for trout.
Hanalei River at end of road, Aug. 16.	84°	69°	12:00 PM	8.1	Midge larvae, damselfly nymphs, opae (reported).	Only oópu.	Nine oópu traps or "kahis" on this stream. Fine water but too warm for trout reproduction.
Limahula Stream just above road to Haena, August 14.	76.5°	68.5°	11:00 AM	6.9	Isopods, torrent and other midges, opae and damselfly nymphs. Food excellent.	Only oópu.	A rich, clean, clear stream but too warm for trout reproduction. No signs of freshets. Eyed eggs of trout should be planted in the head waters of this stream.
Hanakapiai Stream ¼ mile above trail crossing, Aug. 14.	81°	68.5°	11:45 AM	7.0	Midge larvae, opae, damselfly nymphs. Food fair.	Aholehole and oópu.	Fairly steep stream too warm for trout reproduction.

[1] The identification of the various food was as follows:
Terrestrial millipedes, damselfly nymphs and isopods the same as found in the Kokee Area (Table 1).
Opae—*Macrobrachium grandimanus* (Randall).
Torrent midge larvae—*Telmatogeton hirtus* (Wirth).

[2] The common oópu, *Awaous guamensis* (Valenciennes). No trout were found in any of these streams. The aholehole is identified as *Kuhlia sandwicensis* (Steindachner).

[3] Tentatively identified as *Neritina granosa* (Sowerby).

[4] *Lyngbya putealis* Gom.

Torrent midge larvae—*Telmatogeton hirtus* (Wirth).

[4] Tentatively identified as *Neritina granosa* (Sowerby).
[4] *Lyngbya putealis* Gom.

TABLE 4.—WATER TEMPERATURES, pH VALUES, FISHES PRESENT AND OTHER CONDITIONS FOUND IN THE STREAMS OF MAUI

STREAM, STATION AND DATE	TEMPERATURES in ° F			pH	DOMINANT FOODS	FISHES PRESENT	REMARKS
	AIR	WATER	TIME				
Iao above intake to ditch system. August 29.	81°	68°	10:08 AM	—	Millipedes, opae, snails, torrent midge larvae, damselfly and dragonfly nymphs. Food abundant.	Only oópu.	Beautiful stream with good flow. Would support trout for growth if not reproduction. Severe freshets. Stocked with rainbow in 1922.
Honokohau at ditch line, August 29.	83°	67°	2:35 PM	—	Midge larvae (torrent), damselfly and dragonfly larvae. Food fair.	Large trout seen at intake by B. Fleming, spring, 1947. Oópu.	First stocked with rainbow trout in 1922. Apparently too warm for trout reproduction.
Waikamoi at No. 1 Dam flume intake. August 30.	68°	58°	10:15 AM	6.7	Average.	None observed.	Elevation around 4,000 feet. Water temperature in Waikamoi reservoir below here remains less that 60° F. the year round. Should be stocked with trout.
Waikamoi main stream below No. 1 upper dam. August 30.	68°	63°	10:30 AM	6.7	Poor—much like Kokee stream at this point.	None observed.	Steep stream with many falls. Two diversion dams at this station. Little use for fishing because of inaccessibility.
Waikamoi at pumping pool. August 30.	73°	62°	12:00 PM	6.9	Poor.	None observed.	Dam diverts entire flow here to pump. Stream very steep. Beautiful pool of cold, clear water—about 1 or 1½ acres.
Nuuailua at Road Crossing. Aug. 31.	75°	71°	10:30 AM	7.0	Opae, angleworms, midge larvae.	Oópu.	Flow around 2 c.f.s. at this point. Steep with many pools and riffles. Inaccessible to anglers.
Keanae at road crossing. August 31.	77°	69°	11:30 AM	7.7	Univalve molluscs, opae and midge larvae. Food fair.	Oópu.	Fine, clear, clean, cold water stream. Might be suitable for trout spawning if gravel available. Experimental stocking recommended—1,000 eggs. One of the best streams seen on Maui.
Hanawi at Waialua Ditch Stream August 31.	77°	69.5°	2:00 PM	7.3	Torrent midges, opae, damselfly nymphs. Food fair.	Oópu.	Flow approximately 3 c.f.s. High falls ½ mile above road. Too warm for trout reproduction in winter.
Wailua Ditch at Hanawi Stream. August 31.	77°	69°	2:00 PM	—	Same as in Hanawi.	Oópu.	A ditch many miles in length, sections of which could be used for angling or rearing of trout, but too warm for trout reproduction in winter.

fly-fishing for trout not now available. Not a single trout was taken on a fly during the field work though they were tried out frequently. The trout are accustomed to angleworms, shrimp, millipedes and other forms and do not rise to flies, though a few terrestrial flies that fall into the water were occasionally found in their stomachs.

DANGERS OF INTRODUCTION

It is recognized that one most important function of the Board of Agriculture and Forestry is to prevent the introduction of insect or other pests that would be harmful to animal, plant, or human life in the Islands. From this standpoint, so far as is known today, no harm would result from the introduction of mayflies, stoneflies, or caddiceflies, provided swift-water forms only were selected. There would not be any danger of introducing pests if the insects selected were first reared on the mainland and eggs or young of known species were then flown to Kauai uncontaminated with other forms. The only drawback that occurs to us would be the attraction of these forms to lights at night. Many summer homes are built close to streams and doubtless at night during periods of emergence of adults from the water, large numbers would cluster on the screens of houses, around car headlights and other light areas. No doubt they would increase considerably the work of cleaning car windshields but their value to island streams as fish food would seem to outweigh these considerations.

It should be pointed out that the nymphs of mayflies are herbivorous and feed on algae, diatomes and other plant materials of which there is a vast abundance in the streams of the islands. Stonefly nymphs are both herbivorous and carnivorous while caddicefly larvae are often omnivorous, feeding alike on decaying organic matter or stream plankton.

HATCHERY PROPAGATION

In order to meet the temperature problem and at the same time secure an adaptable strain of rainbow for artificial propagation and planting in Territorial waters, three possible solutions are presented: (1) rainbow from the Kokee area could be used; (2) rainbow might be introduced from Mexico; or (3) eyed eggs might be purchased from mainland breeders and flown to the islands each year as they are required.

It would be relatively simple to secure a brood stock of the Kokee rainbow for fish-cultural purposes. These we know are spawning successfully in a foreign habitat and must have already become fairly well adjusted to high, winter water temperatures, at least in Kokee and Kauaikinana streams. Selective breeding of these fish to secure even greater tolerance to high spawning temperatures, might in the long run, produce a strain of trout that could be genetically and physiologically adapted for spawning successfully in many other Hawaiian streams.

The introduction of Mexican rainbows is suggested because, coming from tropic conditions, they might provide fish that would be better adapted and more successful in Hawaiian waters. Nelson's trout (*Salmo gairdneri nelsoni* Evermann) from the Santo Domingo River in Baja, California, is proposed as a definite possibility. The senior author has visited the Santo Domingo

River and collected these trout on three different occasions. Like Hawaiian streams, the Santo Domingo River is subject to tremendous flash floods that occur each winter and carry huge amounts of gravel, sand, rocks, boulders, and trees downstream. Further, the stream presents temperature conditions somewhat parallel to Hawaiian streams. In the month of May temperatures rise to over 76° F. and in the autumn before the advent of winter rains, they must go well into the 80's° F. These fish successfully withstand the harsh environmental hazards there and for this reason might do well in the streams of Kauai and Maui.

Other members of the rainbow series on the mainland of Mexico might also be considered for introduction into Hawaii. Rainbow occur under more tropical conditions in many of the Pacific Drainage streams draining off the main Sierra Madre Mountain range from the Rio Yaqui south to near Matzatlan. The senior author collected several groups of these in the summer of 1952 and they could easily be obtained for experimental purposes after suitable arrangements were made with the Mexican government.

The purchase of eyed eggs from mainland trout breeders is only recommended as a last resort. If this is done, only eggs from spring-spawning fish should be used; eggs from autumn spawners are not recommended.

To prevent the introduction of furunculosis or the "boil" disease (*Bacterium salmonicida* Emmerich et Weibel) of trout into island waters, all eyed eggs received from outside sources should be properly sterilized upon arrival before either being placed in hatchery troughs or in streams.

ANGLING REGULATIONS

The present 3-months season for trout from June 1st to September 1st is satisfactory under present angling pressures but if angling pressure increases greatly, the season should be reduced accordingly.

Because of the desirability of spreading the available supply of trout among as many anglers as possible and the extremely limited stream or ditch areas where they may be caught, plus the danger of possible failure of recruitment of young in some years because of high water temperatures, the bag limit should be reduced from 10 to 5 fish per angler per day.

Although the size limit of 6 inches now in existence does not afford full protection to trout through their first spawning period, it is probably adequate because the bulk of the fish being caught in 1949 were in their third year of life and between 7.5 inches and 10.5 inches in length.

The regulation limiting the catching of trout to flies only should be changed since it is impossible to catch them by this method. The law should be changed so that they may be taken on an artificial lure. All bait fishing using salmon eggs, worms, grubs, or other natural organisms should be prohibited. Obviously, the limited areas of trout fishing make it essential that restrictions be rather rigid, for a greatly increased take of trout would probably seriously reduce spawning reserves.

SUMMARY

1. Rainbow trout are growing and

reproducing satisfactorily only in the upper streams of the Kokee area on the Island of Kauai.

2. Many attempts have been made to establish trout but they have failed in most streams on both Kauai and Maui which have excellent growing temperatures but which evidently lack a sufficiently long period of cold water each winter to permit proper development of the gonads and the production of viable ova.

3. Approximately 90 per cent by number of foods utilized by trout on Kauai are terrestrial in origin. Dominant forms were angleworms, millipedes, red shrimp, and isopods.

4. Dominant aquatic foods as determined from bottom samples were midge larvae (Chironomidae), dragonfly nymphs and aquatic damselfly nymphs (Odonata).

5. The torrent midge larva, *Telmatogeton hirtus*, was found to occur by the thousands on the surface of stones in the swiftest water of all streams below the palis and furnish a rich source of fish food.

6. Ovarian counts of female rainbow trout indicated that an average of 1129 eggs are produced at their first spawning which usually occurs in Kokee Stream at the end of their fourth year.

7. Examination of sectioned ovaries from fish caught in the warmer water areas revealed an arrested state of development.

8. An excessively high ratio of females to males was found in the population sampled.

9. A normal length-weight relationship was found as evidenced by the regression equation $Y = 6.052\ (1.1403)^x$ where Y = weight in grams and X = fork-length in centimeters.

10. Water temperatures in Kokee Stream in 1946 were evidently suitable for natural spawning. This was evidenced by the fact that most of the fish taken in 1949 were from the 1946 brood year.

11. Dragonfly and damselfly nymphs are the principal predators on small trout on Kauai, and with the effects of floods, may be a major cause of the disappearance of rainbow trout from the upper waters of the Waialae, Koaie, and Mohihi streams.

12. Except for the absence of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddiceflies (Trichoptera), aquatic food supplies of the streams of Kauai and Maui are excellent. This is true despite the fact that most of the foods eaten by trout are terrestrial in origin.

RECOMMENDATIONS

1. A thorough study of winter water temperatures should be made in relation to gonad development and spawning of rainbow trout. The data obtained would be of great value in a critical analysis of the temperature problem in relation to successful natural spawning. Selective breeding of the Kokee strain of rainbow is suggested to secure a better adapted fish for Hawaiian waters.

2. Hatchery brood stocks of the Kokee rainbow should be developed for artificial propagation and stocking Territorial waters. If this is done and the fish or eggs are planted properly, a tremendous expansion of trout fishing in island streams could be expected.

3. The rearing of other than eyed

eggs or unfed fry for planting is not recommended except where the need for brood stocks warrants rearing of older fish.

4. Priority in stocking should be given first to streams in the Kokee area above the palis; second to the Hanalei, Lumahai, Wainiha, and other streams draining the northern segment of Kauai, and third to the mid-canyon areas below the palis on both Kauai and Maui.

5. As an alternative or supplement to the development of the Kokee strain of rainbow for hatchery propagation, trout from Mexico could be introduced to provide a strain of rainbow that might reproduce satisfactorily under the temperature and flood conditions found in the streams of Kauai and Maui.

6. To prevent the introduction of furunculosis or the "boil" disease of trout caused by *Bacterium salmonicida*, any eyed eggs shipped into the islands should be properly sterilized upon arrival before being placed in hatchery troughs or streams.

7. Fish ladders and rotary fish screens should be installed where needed to (1) permit safe ascent to upstream spawning grounds and (2) to prevent downstream losses of fish into lower, unsuitable areas.

8. The Board of Agriculture and Forestry should have proper authority to require the installation of fish protection devices when any dam is to be built for any purpose in the streams of the islands.

9. The Board should have plenary powers to regulate bag limits, seasons, size limits, gear, traps and all methods of fishing in order to properly manage the fresh-water fishery resources of the Territory.

10. The bag limit should be reduced from 10 to 5 fish per angler per day.

11. The present law limiting the capture of trout to artificial fly only should be changed to permit fishing with any artificial lure such as spinners, flies, spoons, "flat-fish" or other like gear using no more than two hooks. Bait fishing with worms, fish eggs, grubs or other natural organisms should be prohibited at all times.

12. Lotic water species of mayflies, stoneflies, and caddiceflies should be introduced into freshwater streams of the islands to: (1) furnish a buffer food supply between the predaceous odonatan nymphs and young trout; (2) provide additional sources of fish food; and (3) provide fly "hatches" for fly fishermen.

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Accepted for publication November 10, 1952.

FUNCTION AND OPERATION OF BIG-GAME CHECK STATIONS IN COLORADO

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Introduction

Although big-game check stations have been operated in Colorado since 1938, no previous attempt has been made to evaluate their function in game management and administration. Despite this neglect, public demand for more check stations has grown, due to the general belief that official inspection of kill promotes better law enforcement. Contrary to public belief, check stations in Colorado are now operated by the Game and Fish Department for the express purpose of collecting biological, economic, and other research information. The only exceptions are a few road-blocks on state lines manned by warden personnel.

Acknowledgments

Grateful acknowledgment is made to the Colorado Game and Fish Commission, and to Mr. C. N. Feast, former Director, Game and Fish Department, for the opportunity of undertaking this study. The assistance of many Department employees, particularly Gilbert N. Hunter, Game Manager, E. K. Brown and Laurence E. Riordan, Federal Aid Coordinators, and Velma Merkle, statistical clerk, made possible its completion. Lee E. Yeager, Leader of the Colorado Cooperative Wildlife Research Unit, assisted with preparation of the paper.

History, Number and Location

Until 1938, very little was known about deer and elk populations and harvest in Colorado. Local game wardens and forest rangers estimated numbers and kill, but with little basis for their estimates. Practically all deer and elk were thought to be on Forest Service lands. Thus, in 1930, the Forest Service estimated a total kill of 30 elk and 1,776 deer for the state, virtually all on National Forests. Details of this and subsequent topics are treated in many of the processed quarterly reports of the Federal Aid Section, Colorado Game and Fish Dept., between 1939 and 1950. The Game and Fish Department and the Forest Service set up 28 big-game check stations in 1938, resulting in the inspection of 58 per cent of an estimated 9975 deer killed, and 54 per cent of an estimated 1143 elk killed (Table 1).

Since 1939, the Federal Aid Section of the Game and Fish Department has been primarily responsible for check station operation.

The largest number of stations operated in any one year was 36 in 1948; and the fewest in operation was 3 in 1943.

The Forest Service, interested in kill by forest or ranger district, required a large number of stations to cover as many districts as possible. These, for the most part, were on back roads near district boundaries. The state followed

TABLE 1.—DEER AND ELK RECORDED AT CHECK STATIONS, COMPARED TO THE TOTAL DEER AND ELK KILL AND LICENSE SALE, COLORADO, 1938–1950

Year	Big Game Licenses Sold	Number of Check Stations	Deer			Elk			Percent Big Game Success [1]
			Total Checked	Total Killed	Percent of Kill Checked	Total Checked	Total Killed	Percent of Kill Checked	
1938	24,574	28	5,774	9,975	58	614	1,143	54	45
1939	27,745	27	7,240	14,500	50	768	1,800	43	59
1940	38,090	15	9,366	28,428	33	1,417	2,987	47	82
1943	61,119	3	3,923	30,646	13	582	6,143	9	60
1945	63,190	9	4,851	28,264	17	731	3,355	22	50
1946	112,320	11	20,385	53,265	38	2,170	8,428	26	55
		4 [2]							
1947	98,990	13	21,759	46,666	46	1,740	4,793	36	52
		23 [3]							
1948	113,365	13	33,841	66,676	51	4,522	10,628	43	68
1949	112,824	20	32,572	71,219	46	3,999	8,248	48	70
1950	121,213	15	30,073	65,182	46	3,424	7,446	46	60

[1] Based on total big-game kill compared to total license sale.

[2] Post-season operation for ten days, 731 deer.

[3] Pre-season operation for fifteen days, 11,768 deer.

this method of location in 1939, but changed in 1940 when it was discovered that fewer stations on main roads would check more animals. Relocation on highways presented a new problem, that of warning signs, and, after trying various types in cooperation with the State Highway Department, it was decided that whenever practicable the stations should be within the corporate limits of a town where, due to reduced driving speed, fewer signs would be needed.

Station locations are decided upon after the setting of big-game seasons in May. The eight permanent stations are always set up as a base; the type of season, public pressure, or the desire to block off an area in order to control the kill, are weighed and additional stations set up accordingly.

The Colorado Game and Fish Commission has the legal right to extend or close any season on 48 hours notice, and check stations are used as a guide to the Commission in closing an area where there is evidence of an over-kill. In such cases, the area is surrounded as completely as possible with stations, and when a prescribed number of animals has been reported through them, the Commission invokes the 48-hour statute to stop further hunting. Blocking of an area is also used to check the accuracy of kill-card reports where the return of cards is not 100 per cent and where it is necessary to project the kill on the ratio of successful to unsuccessful hunters. (Hunter and Yeager, 1949).

ORGANIZATION AND MANPOWER REQUIREMENTS

Check stations in Colorado are managed by the Federal Aid Division, under the general supervision of the Coordinator. The Leader and the Assistant Leader for the Big-game Project each supervise stations in one-half of the

state, their responsibility being that of coordinating this work and checking methods used in obtaining information from hunters.

Each large station is in the direct charge of a permanent Federal Aid employee, who must train each shift of temporary employees at his station. He also compiles the data gathered, and reports totals to the Denver office every third day. Under his supervision are from two to eight men, depending on the size of the station and whether it is considered a 16- or a 24-hour operation. The smaller stations, checking from 300 to 400 animals for the season, are operated with two temporary employees, each on an 8-hour shift. Larger stations, checking from 4,000 to 7,000 animals, need from six to eight laborers and, if located on a main highway, will need additional personnel to direct traffic. At all the larger stations, if law enforcement work is to be done, at least two wardens are required or the supervisor will spend most of his time in court, rather than directing the work of his men. Temporary employees are seldom given special warden commissions because their lack of experience and training in law enforcement usually results in incorrect decisions, and thus poor public relations. Temporary employees are recruited whenever possible from nearby towns.

COSTS

To be considered in evaluating check stations is the cost of acquiring data, synonymous to checking successful hunters out of the field. The estimated annual cost of operating the original Forest Service stations was $200 each, not including the salaries of Forest Service, CCC, and State employees. Of this cost, the Forest Service paid 75 per cent and the State 25 per cent. A total of 6,388 animals were checked by the 28 stations checking in 1938, giving an average cost of approximately $0.87 per animal.

In 1939, the Coordinator again converted the cost of check-station operation to cost per animal; the 27 stations active that year handled 8,300 animals at a cost of $0.51 each. This cost, however, included only the salaries of the Federal Aid staff and subsistence for temporary laborers, their salaries being paid out of CCC funds. In 1949, 20 check stations handled 36,307 animals at a cost of $0.32 each. This figure includes cost of labor as well as the salaries and subsistence of the Federal Aid staff, thus giving the truest representation of costs obtained. The cost of checking varies inversely with the number of animals checked.

INFORMATION OBTAINED

In 1938, check station forms included entries for the following:

1. Number of hunters by county of residence.
2. Number of animals killed by drainages.
3. Success ratio by drainages.
4. Kill per square mile.
5. Kill per square mile of sheep range as compared to cattle range.
6. Percentage of kill by antler-point class.
7. Record of swollen necks in bucks by date and number of antler points.
8. Reports from hunters on palatability of meat.

9. Weight and antler development of bucks and bulls by drainages.

In recent years the number of questions asked has of necessity been reduced from those included in the earlier form because the greater number of hunters now checked reduces the time that can be spent with each. Although an attempt has been made to obtain different and useful information each year, questions pertaining to numbers killed by drainages, sex and age ratios, and kill by antler-point class, have remained the same through the years.

RESULTS

Seasons. During the 1930's and later there was a good deal of controversy concerning the opening date and length of the deer and elk seasons. The opening of deer season varied from October 1 to October 15, and the elk season opened as late as November 16 in 1940. Studies indicated no correlation between neck swelling and latitude or elevation. After October 1, the swelling was very evident in the larger bucks regardless of latitude or elevation, although this sign was lacking in 90 per cent of the two-pointers. Hunting cannot begin earlier than mid-October without conflict with grazing interests. Also, warm weather likely to prevail before this date could result in considerable spoilage of meat.

In 1940, the first of a series of antlerless seasons under the permit system was begun. The public immediately raised the question of the ability of the fawns to survive if weaned by an October doe season. Check-station operators were asked to note the condition of the mammae in determining the stage of lactation. Of a total of 2,189 does checked that year, 303 (13.9 per cent) were listed as dry and 231 (10.6 per cent) were listed as wet; but the greater number, 1,655 (75 per cent) were not classified, due to removal of udder in field. Of these, it was probable that a large proportion were wet.

Only one pre-season has yet (1951) been authorized in Colorado. This was for deer in 1948 in the Uncompahgre Plateau and the western part of the Grand Mesa Forest. Although regarded as a success from the standpoint of taking a large number of deer from a limited area, opinion is sharply divided as to its over-all value. A two-deer pre-season tends to concentrate too many hunters, which is dangerous; also, it is reasonable to believe that an equal number of deer might be taken in a two-deer area during a regular season. Since this pre-season area was open to two deer on a license, successful hunters were asked their reasons for hunting there. Some of the hunters seemed to hesitate about answering, perhaps in fear of appearing to be game hogs; and this circumstance may have affected the accuracy of the poll. Of the 11,768 hunters questioned, 33 per cent stated that usually they hunted in the region involved, 42 per cent because of the earlier season, and 25 per cent were in hopes of getting two deer on their license.

Since the 1948 pre-season, two-deer hunt, a portion of the state has been opened to the taking of two deer per license each year. For three years, the number of deer thus obtained has been approximately 10 per cent of the total kill. The success ratio was much lower in a two-deer area than in a regular one-deer area for 1948. In the 1948 two-

deer pre-season, only 38.5 per cent of the hunters were successful and only 47 per cent of these obtained two deer. For the first two years the Commission ruled that of the two deer allowed, one *must* be antlerless and both might be. In 1950, the regulation was changed to include one antlered and one antlerless animal.

The following figures (Hunter, 1950) show the difference this made in the antlerless kill.

	PER CENT		
Year	*Bucks*	*Does*	*Fawns*
1948.....	42.8	41.4	15.8
1949.....	40.0	46.0	14.0
1950.....	50.0	39.0	11.0

A deferred season on elk was allowed in the Hermosa region in 1949, and on deer over the eastern slope in 1950, the Commission ruling that hunting in these areas would begin one week after the opening of the season in the remainder of the state. The season on elk showed a decrease in kill of 12 per cent in bulls and calves, with cows remaining at their previous level, or a total decrease of 17 per cent, based on check-station data. In the deferred season on deer, the Ted's Place station showed a decrease of 31 per cent in doe kill, with bucks and fawns remaining the same, for a total decrease of 15 per cent as compared to the previous either-sex season.

Colorado has tried two post-seasons wherein check-stations were used to evaluate results. One of these was for deer on the Grand Mesa-Uncompahgre forests in 1947; the other for elk at Estes Park in 1949. In both cases the kill was light, but it was considered that post-seasons represent a valuable tool in small areas where heavy hunting pressure is not desired for safety reasons. In the 1947 post-season for deer, only 2,269 animals were killed. In the 1949 post-season for elk, only 98 animals were taken. Fair weather can, perhaps, be blamed in part for the low elk figure.

Kill

The first consideration of the Forest Service in establishing check stations in 1938 was to obtain a basis for estimating the big-game kill, and the number of hunters using the National Forests. At this time all the elk and 98 per cent of the deer were considered as National Forest residents. Even as late as 1940, very little attention was paid to deer populations outside of the National Forest area. In 1939, the Game and Fish Department stated that 9,406 square miles of the state were occupied by deer and the same by elk. This figure does not include the total National Forest area in Colorado. The kill in 1939 for the 9,406 square miles was estimated at 14,500 deer and 1,800 elk, a kill of 1.54 deer and 0.19 elk per square mile. Hunter (1946), in reporting the Colorado big-game kill, listed 46,836 square miles of deer range and 16,392 square miles of elk range in the state. The kill in 1939, based on this larger range, was only 0.31 deer and 0.11 elk per square mile. In comparison, the kill in 1946, (Hunter, 1948) was 1.14 deer and 0.51 elk per square mile.

Two questions were asked during earlier years of station operation to determine the time of day and the day of the season when most animals were shot. Mid-morning hours between eight and ten o'clock showed the peak of the day's kill, although there was a smaller peak, equal to about half of that in the

morning, at four o'clock in the afternoon. During the 10-day season of 1939, 65 per cent of the kill was made during the first three days. In the longer, 17-day season of 1940, it took five days to attain the same percentage. The same rush for opening-day hunting holds at the present time.

Before 1938, the big-game kill estimate for Colorado was made by compiling the individual estimates of the wardens and rangers in the field. After 1938 and until 1944, the kill was estimated through the use of check-station kill data. In 1940, a postcard poll of 10,000 hunters was conducted to determine the accuracy of this information, and the comparison resulted in dissatisfaction with check-station figures. The hunter report-card system was begun in 1944, and is believed to give greater accuracy in estimating big-game harvests. In 1947 and 1948, two areas were surrounded by check stations, and the number of animals checked varied less than 10 percent from the kill disclosed by report cards. Check-station figures are still used to predict the kill, and as a basis for extending or shortening a hunting season on any given area. By taking into consideration the number of licenses sold, and special seasons in certain areas, it is possible to predict the total kill with a considerable degree of accuracy within 3 to 5 days after the season opens. (Hunter and Yeager, 1949). Table 2 shows the use of the eight principal stations in determining kill trends, and their relative accuracy in predicting the kill without considering special seasons.

The difference in kill ratios between an either-sex season and an antlered-only season is clearly shown by the Monarch Pass and Ted's Place stations. In the either-sex seasons of 1946 and 1948, the Monarch Pass station checked 5,811 and 5,286 deer, respectively. In the 1947 antlered-only season, this station checked a total of 2,973 deer. The buck kill during the three years varied by only 600 head, does and fawns representing the increase. The station at Ted's Place tallied 1,634 deer during the 1948 antlered-only season, and a year later jumped to 2,967 deer because of either-sex hunting. In 1949, the buck kill during the either-sex season showed a drop of 300 animals, with a corresponding increase in does and fawns.

TABLE 2.—PERCENT OF ERROR IN PREDICTING DEER KILL FROM EIGHT PERMANENT CHECK STATIONS, COLORADO, 1945-50

Year	Animals Checked Permanent Stations	Percent Change	Predicted Kill	Total Kill from Report Cards	Percent Error
1945	4,645 [1] 9,859 [1]			28,264	
1946	19,629	+112.0	59,919	53,265	12.5
1947	17,895	− 8.8	48,578	46,666	4.1
1948	22,002	+ 22.9	57,352	66,676	13.9
1949	22,472	+ 2.1	68,076	71,219	4.4
1950	22,325	− 0.6	70,792	65,182	8.6

[1] Only 5 stations involved.

The Meeker and Rifle stations did not show this trend under the same conditions, perhaps due to local feeling regarding the killing of does. All stations showed an increased kill in elk when either-sex seasons are compared with antlered-only seasons, varying as much as five times at Monarch Pass, three times at Meeker and Rifle, and a little under three times at Animas.

Age Classes

One item that shows a definite change with the increase in hunters and hunting pressure is the kill ratio of bucks by point class. In 1939, the largest kill was among the four-point class with 36.8 per cent of the total. The two-point class that year was 29.2 per cent of the kill, and 19.5 per cent were three-pointers. In 1940, the kill in the two-point class was highest with 42.5 per cent and has remained fairly constant since; for example, in 1950 the two-point class was 43 per cent of the buck kill by check-station tabulation.

During the earlier years of station operation in Colorado, an effort was made to devise a simple, concise, external measurement that would give the game manager a reasonably accurate sample of the kill by age group and weight condition (Hunter, 1947). To this end, each station classified deer as poor, good, or fat; but it was found that such a classification resulted in varied information due to differences in individual opinion. Following this experience, and still trying to find condition classes, most of the deer and some of the elk were weighed or estimated as to weight. These weights were then tabulated according to point class, and graphs prepared to show the relationship to other factors, such as brow tines, number of points for each antler, and antler diameter, length, spread, and circumference. In later years, additional measurements—length of head, circumference of girth, length to first antler fork, and dentition—were correlated. The final results indicated a definite relationship between number of points, weight, antler diameter, length of antler, and dentition.

By 1946, Hunter (1947) had classified 2,187 deer according to these measurements and published his findings, showing that beam diameter, one inch above the burr, gave the following degrees of accuracy by age class:

Age of Deer Years	*Beam Diameter Inches*	*Percentage of Accuracy*
1⅓ to 2⅓	.50 – .90	97.7
3⅓ to 4⅓	.92 – 1.25	88.7
5⅓ to 6⅓	1.30 – 1.50	76.4

In succeeding age groups not enough correlation was found in any one external measurement to insure reasonable accuracy, although all animals with a beam diameter of 1.5 inches or more may be listed as exceeding the 6⅓-year age group.

It was believed that this simple measurement of beam diameter would reduce human error in estimating age, and also show the percentage of yearlings in the total kill. Such information would give the game manager an indication of fawn survival for the preceding year, because the youngest age classes generally make up most of the kill.

Human error is still evident, however, as indicated by the 1950 check-station survey: In three stations covering the same general area of the Un-

compahgre Plateau, the percentage of yearlings checked varied from 25.1 per cent at Whitewater, 51.8 per cent at 25 Mile Mesa, and 24.4 per cent at Sapinero. The Del Norte, Pagosa Springs, and Animas stations, although in the same general area, were below the state average of 43 per cent yearlings, for here the kill ran from 25.6 to 35.8 per cent on animals in the 1⅓ year age class. If check stations could be manned by permanent employees who would accurately measure all heads, much of this error could be eliminated. Temporary laborers, not realizing the importance of accurate measurements, tend to do too much estimating.

Weights

One point that could not be determined for the early years was the number of deer actually weighed and the number for which weight was estimated. In 1939, the weights given for all point classes of bucks were from 10 to 20 pounds higher than in 1940. In 1939, two-point bucks averaged 115.6 pounds and ranged from 104.6 pounds on the Roosevelt to 126.8 pounds on the Arapahoe. In 1940, the National Forest average for two-point bucks was 106.2 pounds, and ranged from 94.2 pounds on the Gunnison to 111.6 pounds on the Holy Cross. This same age class was listed by Hunter (1948) as averaging 103.5 pounds in 1946 and 101.7 pounds in 1947. One difference in weights between the years 1939 to 1946 is the inclusion of spike deer in the two-point class, with, perhaps, lower weights. It would be interesting and profitable to take actual weights of yearlings in future years for comparison with these figures.

The results for deer and elk weights are not satisfactory, due to estimating rather than actual weighing and lack of comparableness in operation. They emphasize the essentialness of organized and systematic procedure from year to year.

Wounding Loss

In 1947, Laurence E. Riordan, Big Game Project Leader, instituted a series of check-station questions aimed at determining the wounding and abandoning loss on deer and elk. These questions were: 1. Did you wound any animal(s) (deer or elk) other than the one you have here? How many? If so, do you think the animal(s) was fatally wounded? 2. Had this animal been previously wounded by another hunter? 3. Did you see any animals (specify deer or elk and number of each) that had been killed and left lying in the field?

An effort was made to avoid duplication by recording abandoned animals only once for different members of the same party, where it could be ascertained by questioning that they had seen the same animal. When abandoned animals were reported by different hunting parties, it was almost impossible to tell if duplication was involved. This inability to differentiate in such cases could give a higher wounding and abandoning loss than is actually the case.

The crippling loss survey in 1947, showing average losses for deer and elk of 13.8 and 11.7 per cent, respectively, varied widely at individual stations, ranging from 0.8 per cent at the Dam Store station to 20.3 per cent at Monarch Pass on deer; and from 0.6 per cent at Del Norte to 39.2 per cent at Monarch Pass on elk.

During the 1948 pre-season hunt, where the hunting pressure was high and the success ratio low, a decrease to 9.4 per cent was noted in the deer crippling loss. In the regular season, the average loss for deer was 10.7 per cent and ranged from 1.3 per cent at Ted's Place to 22 per cent at Willow Creek. The average loss for elk was 6.8 per cent, and ranged from 0.3 per cent at Ted's Place to 10 per cent at Idaho Springs.

The following year, 1949, the last coverage for crippling loss, a further decrease was noted, the average being 5 per cent for deer and 6.8 per cent for elk. There are two possible explanations for this decrease: (1) hunting was more difficult in 1949 and hunters took what they could get; and (2) hunters became tired of answering this set of questions and gave a "no" answer in order to finish checking more quickly.

Leslie Robinette (unpublished manuscript), working on crippling loss in Utah, reports that of all deer abandonment by hunters, bucks represented only 7 per cent, all other such loss being does and fawns. In Colorado, with an either-sex season on deer and a large area open to either-sex on elk, the abandonment loss reported by hunters was 1,678 deer and 195 elk. Of these numbers, bucks constituted 23.3 per cent, does 52.4 per cent, fawns 23.3 per cent, bulls 33.5 per cent, cows 62 per cent, calves 4.5 per cent, with less than one per cent of the total unclassified by hunters. The same year, 403 deer hunters and 84 elk hunters stated that the deer in their possession had been wounded by another hunter before being taken by them. Of these wounded animals, it was found that 47 per cent were bucks, 38.7 per cent does, and 13.9 per cent fawns. The ratio of wounded elk taken was about the same—41.7 per cent bulls, 42.7 per cent cows, and 15.5 per cent calves.

Hunting Costs

Also included in the checking station survey in 1947 were inquiries aimed at determining the average cost of taking big game, both by resident and non-resident hunters. These figures showed average annual costs of $45.78 to resident, and $114.30 to non-resident hunters, exclusive of license. The costs for resident hunters are about 30 per cent below those given by hunters during the random survey of 1946 and 1947, perhaps because they were contacted in the field (at check stations) and had not figured expenses until the end of the trip (Hunter, 1948).

Examination of returns submitted by 800 hunters during the 1938 season indicate that the average man spent three and one-half days hunting, at a cost of $25 for the trip (U.S. Forest Service, 1938). Since it was estimated that there were 20,000 hunters in the field during the season, this means that Colorado's big-game season resulted in an expenditure in 1938 of about $500,000 for such items as gas, oil, horse hire, hotel accommodations, food, supplies, guide service, and hunting equipment. In comparison, the 1946 expenditure totaled about $6,849,963.00. (Hunter, 1949). The cost of the hunting license was not included in either report.

Hunters

The check station questionnaire in 1950 was directed toward determination of the percentage of repeat hunters, as

compared to those who had not hunted before or who did not hunt every year, and also the number who carried both deer and elk licenses. In station reports for 1939 and 1940, Carhart reiterated his belief that Colorado had reached a maximum in license sales and hunting pressure, and the figures for 1938 to 1945 seemed to support this belief by their slow increase. In 1946, with the end of the war and return of a large number of young men, license sales were doubled over any previous year. The years 1946 to date have seen another static period in the number of licenses sold in Colorado, (Table 1). Despite this indication, Game and Fish Department personnel felt that many new hunters, or hunters who hunted only every second or third year, were in the field each season, and that this number, if known, might supply an index to future sales or reduction in sales, and therefore income, in case of war or other major influence. The 1950 inquiry showed that 30.3 per cent of resident hunters had not hunted the previous year, and that 56.7 per cent of the non-residents had not hunted in Colorado in 1949.

Resident and non-resident hunters were also asked if they carried both deer and elk licenses. Only 19.2 per cent of the non-residents, compared to 27.4 per cent of the residents, carried both. The high cost of licenses for non-residents ($40 for deer and $50 for elk) probably accounted for the lower percentage of hunters holding both permits. The question, therefore, yielded good information on the net number of hunters in the field as compared to the total license sales. Further, it revealed that 25.5 per cent of Colorado big-game hunters carry both a deer and elk license.

Finally, in what was heavier hunting pressure than an average year, non-resident hunters in 1950 purchased 11 and 14 per cent of the total deer and elk licenses, and made 12 and 16 per cent of the total deer and elk kill, respectively, based on hunter report card results. However, a higher percentage (21 per cent) of the successful hunters checked were non-residents, this differential probably being due to the greater distance traveled by non-residents and hence the greater likelihood of their being contacted at a check station. This fact should be considered in the evaluation of future check station data.

SUMMARY

1. Although big-game check stations have been operated in Colorado since 1938, no summary of results has hitherto been made.

2. In 1938, the U.S. Forest Service set up 28 big-game check stations and handled an estimated 58 per cent of the deer, and 54 per cent of the elk kill. In 1939, the Colorado Game and Fish Department assumed responsibility for check-station operation, although the Forest Service and the Grazing Service cooperated for several years afterwards by making available CCC labor crews.

3. Station location has varied considerably during the 14-year period of operation, but 8 major stations are still manned on their original sites. The largest number operated was 36 in 1948; the fewest was 3 in 1943. All stations are now located at strategic road intersections, usually near towns, and where large hunting areas can be controlled.

4. Stations are operated by the Federal Aid Division and are handled

by one to 3 or 4 permanent Federal Aid employees. Local laborers are hired to assist with the more routine station duties. According to importance, stations are operated 16 to 24 hours, and handle 300 to about 7,000 animals during the season. The larger stations are manned by a total of 9 men, including wardens.

5. Cost of operation per animal varies inversely with the number of animals checked, the most valid figure yet obtained, involving 36,307 deer, elk, and black bears, being $0.32 per head. The figure includes all salaries and miscellaneous costs and subsistence for permanent employees.

6. Information obtained at check stations includes number of deer, elk, and bear by drainages, sex and age ratios, kill by antler-point classes, hunting success by species, and kill per square mile of range.

7. Check station data have shown that big-game hunting cannot begin in Colorado before mid-October, due both to the conflict with grazing interests and the probability of warm, unfavorable hunting weather.

8. The one pre-season so far permitted in Colorado resulted in heavy deer kill on a critical area, but opinion is sharply divided as to its over-all value.

9. Various other seasons show that hunting pressure and kill can be manipulated. Thus, two-deer areas, delayed opening dates, and extension of seasons, serve to push hunters into, or restrict them from, specific areas, thereby serving management interests. Post-seasons have generally proved unsuccessful in achieving large kills.

10. Through check stations it has been possible to measure the steady increase in deer and elk kill in Colorado. In 1939, an estimated 14,500 deer and 1,800 elk were taken, based on check station returns; in 1950, the kill was estimated at 65,182 deer and 7,446 elk, based on hunter report card returns. The variation noted in the elk kill can be correlated with the type of season permitted—bulls only, either sex, etc. The kill per square mile by drainages and by counties, for both deer and elk, can be calculated from the data obtained.

11. About two-thirds of the total kill for both deer and elk is consistently made during the first three to five days of the season. Mid-morning hours—8 to 10 o'clock—were most productive.

12. Eight principal stations are used in determining the annual trend in kill, and thus providing the information required for extending or closing seasons, on 48-hour notice, for given areas.

13. The differences in sex ratios in both deer and elk, as affected by types of season, were determined from check station data. In general, hunters showed a tendency to take buck deer and cow elk.

14. Age classes of deer were determined from dentition and beam diameter data. Since 1940, when systematic information began to be accumulated, the predominant age class represented in the kill was the 1½-year-olds, a condition indicating satisfactory reproduction.

15. No accurate data on weights have been taken, due both to the time required for this operation and the lack of facilities for insuring accuracy.

16. Crippling loss in both deer and elk showed considerable variation by stations and from year to year. The most valid figures obtained from hunters questioned at check stations was in

1947, when average deer and elk losses were 13.8 and 11.7 per cent, respectively. This is lower than comparable figures obtained in other states.

17. Big-game hunting costs in 1947, exclusive of licenses, varied from $45.75 for residents to $114.30 for non-residents. In 1938, the average cost per trip was estimated at $25.00. The overall expenditure, exclusive of license, has thus varied from about $500,000 in 1938 to about $6,849,963 in 1946.

18. Big-game license sales in Colorado have increased from about 25,000 in 1938 to about 121,000 in 1950, the greatest increase being in 1946. In 1950, 30.3 per cent of resident, and 56.7 per cent of non-resident, hunters did not hunt in Colorado during the previous year; and 25.5 per cent of all big-game hunters in Colorado carry both deer and elk licenses.

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Accepted for publication December, 1951.

NOTES ON RELIABILITY OF SOME FISH TAGS USED IN MASSACHUSETTS

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The Problem

Data on pond fish populations in Massachusetts waters reveal widespread overpopulation by pan fishes. Casual observation suggests, too, that anglers reap a disproportionately high harvest of predators compared to pan fishes. Investigation of actual harvest rates was initiated by the writer in 1950, which will be reported on later.

An early handicap was lack of a generally usable tag for pan fishes. Initial experimentation with small (No. 1) strap tags attached around the maxillary bones of white perch was almost entirely abortive. In this experiment 106 tagged and 102 untagged white perch (eight-inch average total length) were released on May 1, 1950 in a fertilized half-acre drainable pond at

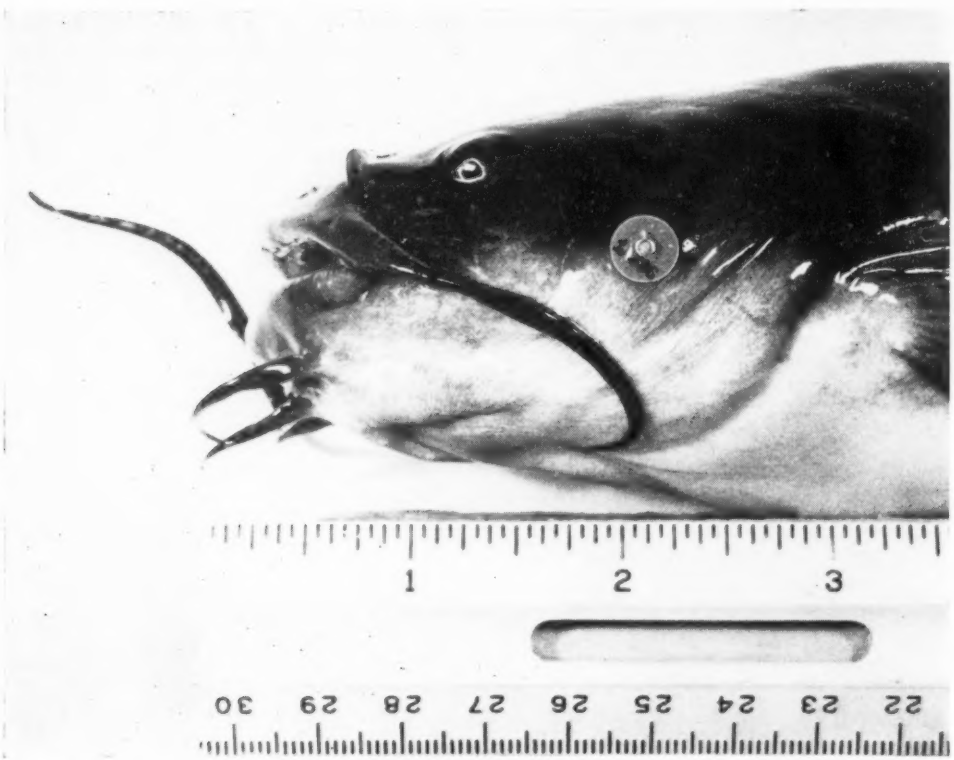

Fig. 1. Cheek tag attached to a brown bullhead 11.8 inches in total length and 0.72 pounds in weight. Right maxillary barbel is curled over top of snout.

Upton. Untagged fish outnumbered tagged fish 34 to one by October 17, 1950. These results agree with those reported by Bardach and LeCren (1948) for yellow perch. These workers suggested, instead, attachment of strap tags to preopercular bones. While promising, it is difficult to accomplish under field conditions in cold weather.

The cheek tag described by Cable (1950) for use on Atlantic shad (*Alosa sapidissima*) in the Connecticut River came to the writer's attention. Utilization on Massachusetts pond fishes (Fig. 1) was initiated in 1950.[1] By the end of 1952 some 8000 cheek tags were used with encouraging results on eastern brook trout, rainbow trout, brown trout, yellow perch, white perch, and brown bullheads; poor adaptability to chain pickerel and largemouth black bass [2] was apparent. Strap tags attached around maxillary and premaxillary bones of black bass have been used satisfactorily by several investigators. About 8000 such tags were used through 1952 in Massachusetts for bass and chain pickerel.

Limited experimental and empirical data are presented here that contribute to ultimate evaluation of tag reliability on various species. The following material is intended as a progress report on this aspect of tagging in Massachusetts.

CHEEK TAGS

Trout: Eighteen hundred eastern brook, rainbow and brown trout from 9 to 26 inches total length were cheek-tagged during February 1951 and liberated later. Recaptures were made by anglers through the trout season until near its close July 31. About 2200 more were tagged in 1952 and released. To check possible differential mortality induced by the tags, as well as possible tag loss, 100 eastern brook trout from 9 to 11 inches (10 inch average) total length were cheek-tagged and segregated in a pool at the Sandwich State Fish Hatchery October 3, 1950. Another 100 brook trout (of similar size and untagged) were added as controls.

First check of these fish was made March 15, 1951. There were 93 controls and 91 tagged trout remaining. A second check October 17, 1951 revealed 56 controls and 51 tagged fish remaining. Final check was made March 30, 1953, when two tagged fish in good condition and one control remained. Presence of the tag appears to have had little or no effect on mortality under hatchery con-

[1] This is a kind of "bachelor button" tag as classified by Rounsefell and Kask (1945). The tag consists of a stainless steel rivet and a plastic disc. Original specifications were supplied by Lyle M. Thorpe of Connecticut as follows: Rivet—Head round 5/16″ diameter x 0.020″ thick, shaft 5/16″ long x 0.062″ diameter. Shaft terminated by a depression 3/32″ deep x 0.048″ diameter, w/0.007″ wall for crimping. Stainless steel type 303 or 18 – 8. Disc—Red opaque vinylite 0.010″ thick 5/16″ diameter, w/hole 0.072″ diameter in center. Letters and numerals in black, covered both sides by lamination of transparent plastic film 0.005″ to give total thickness of 0.020″. Experience soon showed that centering of hole should be specified within 0.005″ of true center. Thickness of vinylite should be increased to at least 0.015″ or possibly 0.020″ before lamination. Semi-automatic applicating pliers must be built to handle tags actually used or jamming may occur. See Cable (*op. cit.*) for details of pliers for application.

[2] *Salvelinus fontinalis*, *Salmo gairdneri*, *Salmo trutta*, *Perca flavescens*, *Morone americana*, *Ameiurus nebulosus*, *Esox niger*, and *Micropterus salmoides*, respectively.

ditions for two and one-half years. Tags remained securely in place. Average length of controls October 17 was 12.7″ while that of tagged experimentals was 13.9″. At termination the tagged fish were 15.6 and 16.0 inches and the control 13.8 inches long.

Chain pickerel: Efforts to utilize five-sixteenths-inch rivets demonstrated they are too short for pickerel over 14 inches if further growth is to be considered. Nevertheless 27 chain pickerel 12 to 14 inches long were tagged with cheek tags. They were released in a 60-acre drainable pond December 19, 1950. Five hundred of similar size (untagged) were released as controls.

Survivors were recovered by drainage between October 15 and October 24, 1951. Eight (29%) cheek-tagged pickerel were recovered; 206 (41%) untagged pickerel were recovered. All recognized tags were partly obscured by overgrowth of cheek tissues. Overgrowth occurred when increased size of fish took up the slack in tags. It is possible that more cheek-tagged pickerel were recovered but not recognized due to complete overgrowth of the tag. Overgrowth is a serious disadvantage. Even so, the difference in recovery of tagged fish and controls is not statistically significant. It is nevertheless apparent that if this happens in the field it is highly significant to evaluation of tag returns.

Average growth increment of tagged pickerel was 1.1 inches. Based on measurement of 136 fish, recovered "controls" grew 1.3 inches on the average during the test interval. On the other hand, six cheek-tagged specimens released November 22, 1950 in 52-acre Duck Pond, Groton (Middlesex County) were recovered by anglers 13 months later. They ranged from 12.5 to 16.5 inches when released and were 17 to 20 inches (angler reports) when recaptured. One male fish was 12.5 inches total length when tagged November 22, 1950 and measured 18.5 inches when recaptured December 24, 1951. Four more recaptured here after 14 months had grown 2.3 inches on the average. One more, recaptured after 17 months, had grown 3.0 inches. McCabe (1948) reports that two years are required for pickerel to increase from 12.7 to 19.2 inches (2.75 inches per year) on the average in central Massachusetts ponds.

Yellow perch: Considerable success was experienced with cheek tags on yellow perch. Limited tag supplies precluded extensive field tests until late 1951 so that few long-range results are available. One hundred yellow perch from 7.5 to 12.0 inches (8.9 average) were cheek-tagged and released in the same drainable pond December 19, 1950 together with 1000 of similar size untagged as controls.

Upon drainage a year later 67 (67%) tagged and 824 (82%) untagged perch were recovered apparently in excellent condition. Again differences in recovery from this small group of experimentals and "controls" lack statistical significance. Larger test groups are obviously needed. All tags had sufficient slack remaining to permit additional growth. Average increment of tagged perch was 0.2 inches. The maximum individual increment was 2.0 inches. Based on measurement of 68 "controls" they also grew 0.2 inches during the year. There is some doubt in the writer's mind that this was a truly representative sample of the untagged perch. It is known, how-

ever, that fish in this pond were badly overcrowded. McCabe (*op. cit.*) reports average annual growth increments of 0.9 inches for fish of this size in 63 lakes of central Massachusetts. None of these lakes, however, are believed to have been as badly overcrowded with panfish as the pond in question.

All tagged perch recovered were returned to the pond. They were supplemented by several hundred additional tagged fish and controls. Further evaluation will be made at the close of 1953 when the pond will be drained again.

Few tagged yellow perch have as yet been available to anglers more than one fishing season. Too, angler harvest appears to be at a very low rate—perhaps one-tenth or less that of pickerel. Four perch were recovered in a creel census at Cheshire Reservoir, Cheshire and Lanesboro (Berkshire County) nine months after tagging. Average growth was 0.4 inches. Two perch were reported caught by anglers from Winter Pond, Winchester (Middlesex County) 11 months after tagging. They apparently grew one-half inch apiece after tagging.

Brown bullheads: No records will be available for tagged bullheads in drainable ponds until the close of 1953. An opportunity for field tagging occurred when many bullheads were trapped in fyke nets October 2, 1950 at 365-acre Stockbridge Bowl, Stockbridge (Berkshire County). Some were cheek-tagged at this time; a few were recovered by anglers the following summer. Recoveries included one fish that had bled profusely from a lacerated gill suffered accidentally during tagging.

Fyke nets were reset there one year later. Sixteen out of 76 tagged bullheads possibly present were recovered within one week. Recovered fish and their tags were in excellent condition. Sufficient slack remained in all tag assemblies to permit further growth. When tagged these 16 fish ranged from 10.7 to 14.6 inches long (12.6 average). When recovered they ranged from 11.1 to 15.0 inches (13.3 average). Average length increment was 0.7 inches; increments ranged from 0.25 to 2.0 inches. Under closely similar circumstances 19% of 92 tagged bullheads were also recovered one year after tagging in fyke nets set in 418-acre Cheshire Reservoir. Growth was similar. Growth rates for untagged brown bullheads are unknown in Massachusetts at present.

In the writer's considered opinion recovery in this manner of 19% to 21% of remaining bullheads suggests that these tags did not induce significant increases in bullhead mortality.

JAW TAGS

Many workers are reluctant to employ strap tags as jaw tags for predator species. This reluctance seems to spring from two sources: first, lack of actual experience with these tags and, second, popular belief that any jaw tag must necessarily inhibit feeding to the extent of inducing significant differential mortality. This idea is widespread despite successful harvesting studies employing jaw tags to assess black bass, sauger, and walleye populations. The following data suggest this fear may be ill-founded at least in part.

Smallmouth black bass: A number of adult smallmouth black bass (*Micropterus dolomieu*) were caught in fyke nets and transferred from North Watuppa Reservoir, Fall River (Bristol County) to 640-acre Mashpee and Wakeby Pond,

Sandwich (Barnstable County) May 22, 1951. They were tagged with No. 3 strap tags affixed around the maxillary and premaxillary bones. Some were removed by anglers that summer. Of 60 tagged smallmouths possibly left, seven were recaught in fyke nets four months later. These particular fish were from 12.5 to 15.5 inches when stocked and from 14.0 to 17.0 inches when recaptured. Minimum individual length increment was 1.0 inches; maximum was 2.0 inches. Average increment was 1.5 inches.

Altogether more than 3000 smallmouths have been tagged, about 81% during 1952. Eight smallmouths recaptured 12 to 15 months after tagging are known already from five different waters. Two each were recovered from 36-acre Beck Pond, Hamilton (Essex County), 269-acre Billington Sea, Plymouth (Plymouth County), 25,000-acre Quabbin Reservoir (Worcester County), and one each from Stockbridge Bowl and 212-acre Forge Pond, Westford (Middlesex County). Six of these fish are known through voluntary angler reports and two through creel census. Range in size when tagged was from 10.5 to 13.9 (12.5 average) inches; recovery reports indicated growth averaging 3.0 inches since tagging.

McCabe (*op. cit.*) gives 2.1 inches as average annual increment of smallmouths in central Massachusetts.

Chain pickerel: Superficial examination of pickerel suggests that strap tags will probably be shed from their maxillary bones in a relatively short time. This has failed to occur in most cases. In this writer's opinion data given by Foote and Blake (1945) precluded reliable results with strap tags in their study of pickerel in Babcock Pond, Connecticut. They attached strap tags, unrounded, to the mandibular bones. No other attempts at tagging pickerel seem to be on record.

About 3300 pickerel were tagged with jaw tags in Massachusetts through 1952. Known annual recovery by anglers has been astonishing (up to 60%) in some instances. Partly for this reason only 29 recoveries of tagged pickerel a year or more in the water are known. Eighteen of these were jaw-tagged—seven from Cheshire Reservoir, five from Stockbridge Bowl, four from Duck Pond and six from Billington Sea. One male from Cheshire was recovered in a fyke net 19 months after tagging that had grown 2.2 inches. It was released again at a length of 19.2 inches. Five more were recorded by a creel census agent after 15 to 16 months. Four were females 17.5 to 18.5 inches at tagging; their average growth was 2.8 inches, to recapture. The fifth was a male 17.5 inches, 2.2 inches longer than at tagging. A seventh fish (male) was recorded that was tagged 26 months earlier. It was 20.2 inches when recovered and 17.8 inches when tagged. At Stockbridge Bowl one recovery (male) was in a fyke net 12 months later. This fish was 12.7 inches when tagged and 16.7 inches when recovered. The remaining four long-range recoveries (three males and one female) were recorded in a creel census 13, 14½ (female), 15, and 24 months after tagging. These fish were 12.0, 18.1, 15.5, and 16.7 inches, respectively, when tagged; they were 4.4, 2.1, 2.6, and 4.3 inches longer, respectively, when recaptured. The four from Duck Pond were all females recaptured after 13 months interval and

reported voluntarily by anglers. Their reports indicated an average length increment of 2.8 inches. These fish had ranged from 14.5 to 16.5 (15.6 average) inches when tagged. Two females from Billington Sea were recaptured after 12 and 13 months. They were 18.0 and 21.5 inches when tagged and 2.5 and 2.9 inches longer, respectively, when recovered,—the former by an angler, the latter by partial poisoning.

That neither differential mortality due to tagging nor progressive tag loss are significant factors in failure to recover more tags after a year or longer is suggested by data for a single small group of tagged experimentals. Twenty-five jaw-tagged pickerel ranging from 14.0 to 17.0 inches (15.8 inch average) were released December 19, 1950 in the drainable pond. This pond is closed to angling but some angling is believed to occur. When drained 10 months later 12 (48%) were recovered. They ranged from 16.0 to 19.9 inches and averaged 18.1 inches on recovery. Average length increment was 2.3 inches. Untagged pickerel similarly released and recovered (41%) at the same time appeared to have grown 1.3 inches on the average. This is inconclusive, however, since the sexes were not separated in the "control" group. It is possible that "controls" were predominately males. Tagged ex-experimentals were mostly females and were larger. Sexual differences in growth of pickerel occur but are not recorded. Reproduction of pan species was poor in this pond due to overcrowding. It is possible that these jaw-tagged pickerel showed superior growth because they were larger and could eat yearlings to better advantage.

Yellow perch: Despite previous indications of dubious merit of jaw tags on yellow perch a few were maxillary-tagged with No. 1 strap tags at Stockbridge Bowl in September 1950. It was felt that results might be valid to the close of the ensuing ice fishing season (February 15). Recovery was made in fyke nets one year later of four out of 47 tagged perch previously unaccounted for. These appeared in excellent condition. There were no signs of irritation at points of tag attachment. This was surprising and suggests possible need for reexamination with yellow perch.

DISCUSSION

Strap tags attached to the upper jaw appear to have considerable validity on chain pickerel as well as on black basses. There was no evidence, during time spans involved, that maxillary tagging causes significant differential mortality. It is uncertain that they caused any significantly retarded growth among these species. Tags properly applied remained on the fish. This method seems almost worthless on white perch and yellow perch artificially confined in small ponds. There is some possibility of increased validity on pan fishes in natural waters.

Possible explanation of differences observed for jaw tags among various species may rest with feeding habits. Both basses and pickerel are fish-eaters as a rule. White perch and yellow perch forage extensively on bottom organisms. Active contact with the bottom during feeding would undoubtedly induce considerable mechanical tag movement. This would cause its gradual migration over the distal end of the maxilla. Tag movement is at maximum in experimental ponds lack-

ing small forage fish. Both white perch and yellow perch are forced to forage for bottom organisms when small fishes are lacking. The latter are extensively utilized as food by these species when available. It is obvious that minimum mechanical tag movement would occur while ingesting fish. This abnormality of the experimental pond may negate to some unknown extent tagging experiments conducted in them unless a supply of small forage fishes is maintained.

Cheek tags proved useful on yellow perch, white perch, brown bullheads, and eastern brook trout, brown trout, and rainbow trout. There is no significant differential mortality or apparent retardation of growth due to its attachment. No tag loss was observed. No difficulty was experienced by tagging the first three species. This is in part due to slow growth rates of these species. Rapid growth of fish like chain pickerel often resulted within a year in complete overgrowth of the external plastic disc *in situ*. For this reason it was discontinued with pickerel. Two fast growing trout under hatchery conditions exhibited similar overgrowth one year after tagging. The 49 visibly-tagged experimentals remaining at one year were in excellent condition with adequate tag slack left despite considerable growth.

Many tagged trout were retained for a month prior to stocking. Some tag loss was experienced at the hatcheries. The tagged fish weighed 2 to 6 pounds each. Considerable fighting occurred among males. The bright red plastic discs employed were a focus for attacks by one fish upon another. Resulting loss from tag destruction prior to planting was about 2.5 per cent for rainbows, 3 per cent among browns and one per cent among eastern brook trout. Lost tags were broken approximately across their greatest diameters. They were easily seen and recovered from the pools. A similar phenomenon was described by Calhoun, Frey, and Hughes (1951) for Petersen tags among spawning salmon. In Massachusetts a total thickness of discs of 0.020 inches was apparently satisfactory on pan fishes. Increase in thickness to 0.025 or 0.030 inches would probably overcome breakage on trout. No corrosion of stainless steel rivets in fresh water or deterioration of vinylite discs was observed.

If large numbers of trout were to be tagged and held in pools for later shipment some kind of nets would have to be devised to prevent tags from fouling in the twine. This is a very serious disadvantage for use where the fish must be rehandled with nets after tagging. It is believed that this problem can be solved using extremely fine-meshed orlon or nylon netting or porous canvas or rubber sheeting.

The chief criticism by this writer of the cheek tag is its expense. Cost runs five times that of strap tags. Necessary special pliers for semi-automatic feeding of plastic discs must currently be custom-made due to limited demand. On the other hand value of data derived from using reliable tags well justify the additional cost. In any case, these tags are cheaper than large staffs of creel census agents. Use of the semi-automatic tag applicator, —particularly in conjunction with drugged fish (Gerking 1949)—permits two men to tag about 200 fish an hour with ease, even in cold weather.

ACKNOWLEDGEMENT

Lyle M. Thorpe, Supervising Fisheries Biologist, Connecticut State Board of Fisheries and Game, supplied specifications and sources of manufacture of components of cheek tags and of special pliers. Dwight A. Webster, Cornell University, reviewed the manuscript and computed statistical significance of comparative recoveries of cheek-tagged experimental pickerel and perch recovered from the drainable pond.

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Accepted for publication February 6, 1952.

A STUDY OF WATERFOWL PRODUCTION ON ARTIFICIAL RESERVOIRS IN EASTERN MONTANA [1]

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Introduction

Through the efforts of federal agencies (P.M.A. and S.C.S.) and private landowners, a large number of stock-water ponds and irrigation dams have been constructed during recent years in the semi-arid portions of eastern Montana. The program is still in progress. Brown and Thoreson (1951) estimated there were 40,000 artificial ponds of 50 acres or less in the entire state in 1950.

An attempt is being made to evaluate waterfowl production on these areas in eastern Montana. In the spring of 1949, three areas in three counties (Musselshell, Carter and McCone) containing about 50 ponds each were selected by personnel of the Wildlife Restoration Division of the Montana Fish and Game Department and the Missouri River Basin Studies, Billings, Montana, as being representative for study. During the next 3 summers, the writer gathered information between May 18 and Sept. 9 (1949, June 26 to Sept. 9; 1950, May 18 to Aug. 14; and 1951, May 24 to Aug. 27) on 124 that proved to be more or less permanent.

Most of 1949 was spent locating the reservoirs and charting them on a prepared map of each area. In 1950 at least 2 visits, about 5 weeks apart, were made to each reservoir. In 1951 the entire summer was spent visiting each area by car at approximately one-month intervals. At least 4 visits were made to each reservoir. Twelve, 4 in each county, were selected as being representative of sizes and vegetative types for more detailed study. Each had produced waterfowl during the previous summers. Eight or more visits were made to each of these special study ponds.

The writer wishes to express his thanks to the Montana Fish and Game Department for financing the project; to Wynn Freeman for the initiation of the project, and general supervision throughout the study; to Gerry Salinas, Joe Mazuranich, Henry Ritzer, and Bob Cotner for field assistance; to Dr. W. E. Booth, Montana State College, for verifying the identification of plant collections; and to Adrien L. Hess, Montana State College, for aid in statistical treatment of the data. Further appreciation is extended to Dr. Don C. Quimby, Montana State College, for advice during field work and assistance in the preparation of the manuscript.

Description of Areas

The climate of eastern Montana is characterized by heavy spring runoffs

[1] A joint contribution from Montana State College, Agricultural Experiment Station, Project No. MS844, Paper No. 283 Journal Series and the Wildlife Restoration Division, Project 39R, Montana Fish and Game Department.

followed by dry summers. Yearly rainfall recorded for all weather stations (Maughan 1941) in the three counties averaged 13.66 inches. Forty-three and four-tenths per cent of the yearly moisture was received in April, May and June; 27.6 per cent in July, August, and September. After filling in the spring, usually the water levels of the reservoirs gradually recede as the summer progresses, some drying completely. Infrequently summer rains refill the ponds or maintain the water levels.

The sparsely-populated Musselshell and Carter County areas consist mostly of unglaciated, rolling, sagebrush-grassland hills interrupted by eroded gullies and drainage bottoms. A strip of ponderosa pine occupies the sandstone ridges of the southern one-third of the Musselshell area, which contains only eight reservoirs. The Carter county area is for the most part treeless except for scattered box elder and cottonwood along the drainage bottoms. All streams are intermittent, flowing only during spring runoff or heavy summer rains. Livestock raising is the principal economy in both areas. The reservoirs are utilized largely for stock water and in most cases furnish the only water supply throughout the summer. Erosion is high and silting common.

About one-third of the McCone County area is under dry-land strip farming. Wheat is the main crop. Sagebrush is lacking on the treeless, grassland terrain. Reservoirs are used for both stock water and erosion control. One was used for irrigation. Several small intermittent streams which bisect the area have water standing in much of their length throughout the summer and contain water after many of the nearby reservoirs have dried.

The average distribution of the ponds is about one per 4 square miles.

PHYSICAL CHARACTERISTICS OF THE RESERVOIRS

Size

The surface acreage of all ponds was roughly determined by drawing them to scale on graph paper and measuring with a planimeter. The dimensions of the ponds were determined by calibrated pacing. Aerial photographs of 3 ponds were taken at about the same time the above measurements were made as a check on their accuracy. All measurements were within 5 per cent.

The range in surface acreage of 124 ponds was 0.1 to 19.1 (mean 3.2) acres. Sixty-five (52.4%) were 2 acres or less. Only 6 (4.8%) were larger than 10 acres. The ponds were grouped into 5 size groups as shown in Table 1.

TABLE 1.—SIZE GROUPINGS BY COUNTIES OF 124 PONDS.

Group	Size range (in acres)	No. of Ponds			Total
		Musselshell	Carter	McCone	
1	0 – 1.05	12	19	6	37
2	1.05 – 3.05	14	16	15	45
3	3.05 – 5.05	9	4	7	20
4	5.05 – 10.05	8	2	6	16
5	10.05 & more	1	2	3	6
		44	43	37	124

Depth

Depth was determined by sounding for the 12 special study reservoirs. The average maximum depth (at "normal" water level) was 6.9 ft. (4-10). The average depth, in most cases, was considerably less. The area surrounding the original creek bed of many reservoirs is flooded during "normal" water. Silting has a tendency to level off the reservoir floor. Contour maps of 4 reservoirs over 9 years old and of one 3 years old showed neither a sharp demarkation of the bottom nor an old channel.

pH

All pH determinations were made with a Taylor Colormetric Comparator. In 1950, 105 determinations were made on as many reservoirs between May 18 and Aug. 21. All were alkaline, 7.7 to 9.4. Some samples were higher than 9.4 but equipment to measure higher values was not available. In 1951, 45 determinations were made on 16 ponds from May 26 to Aug. 27. Readings averaged 8.9 (6.9-10.2). Four readings for different months were taken on each of 5 reservoirs. These indicated that the alkalinity increased through July and then decreased slightly during August (May av. 9.0; June, 9.4; July, 9.5; Aug., 9.1).

Turbidity

Turbidity for special study reservoirs was determined with a 20-cm., black-and-white-quartered Secchi disk during 1951. Depths of 42 readings is given in Table 2. All ponds were muddy following spring runoff, but generally cleared as the summer progressed. Sometimes late summer rains and plankton growths increased the turbidity.

Construction of Dams

All dams were earth-filled, the dirt being taken from the bottom of the reservoir or from nearby. Nine reservoirs had been rip-rapped with rock. Four had fences which were not effective through lack of repair. One dike was protected by a brush wave-breaker and one by old rubber tires. Some ponds were without spillways. Others had dirt cuts. A few spillways were lined with rocks and many had grown to grass.

Seepage

The water may drain out of some ponds within a short period after filling. Others may leak slowly throughout the summer giving rise to small seep areas below the dike. Forty-six ponds had seep areas, none of which exceeded ¼ acre, and most were much smaller.

TABLE 2.—RESERVOIR TURBIDITY READINGS IN 1951.

Date	Number of readings	Average turbidity (inches)
May 26 – June 7	12	25.2 (6–47)
June 15 – July 1	12	32.0 (2.5–50*)
July 11 – July 27	10	35.0 (13–59)
Aug. 14 – Aug. 27	8	21.8 (2–45*)

* Disk visible at bottom of pond.

Age

Ages, obtained from P.M.A. records and landowners, of 88 ponds averaged 8.2 years. Seventeen were from 1 to 4 years old; 45 (51%) from 5 to 10 years old; and 26 from 11 to 18 years old.

VEGETATIVE CHARACTERISTICS OF THE RESERVOIRS

The principal plant species growing in and adjacent to the reservoirs were collected over the three-year period. They were identified and representatives of each deposited in the Herbarium of Montana State College. Quantitative descriptions of vegetation were confined to the 12 selected reservoirs. One-quarter square-meter and one-square-meter quadrats were used on the emergent vegetation; point transects and line intercepts on the adjacent vegetation. Monocot terminology is based on Booth's (1950) Flora of Montana, Part 1. Dicots follow Gray's Manual of Botany, (Fernald 1950) 8th Ed.

Adjacent Vegetation

Ninety-seven 100-point transects (Coupland 1950) were made at regular predetermined intervals around the shoreline of 10 reservoirs (one of the 12 was bordered by a hayfield, another by a grain field). A stick with 10 nails spaced at 10 cm. intervals was placed on the ground parallel with the shoreline. The area where each nail touched the ground was considered a point. The vegetation touching the nail was recorded. The first 10 points for each 100-point transect were taken at the "normal" waterline; the others at 3-pace intervals perpendicular to the shoreline. The average density for all transects was 55.4 per cent. Seven species, western wheatgrass, blue grama, saltgrass, buffalo grass, Sandberg bluegrass, and two species of needlegrass made up 74.4 per cent of the total ground density (Table 3).

Forty-three 50-foot line intercepts (Canfield 1942) were made on sagebrush and greasewood cover on 4 reservoirs (Musselshell 3, Carter 1) parallel to the point transects. A 50-foot string was stretched above the vegetation. The shrub canopy beneath was recorded in inches by species. Then the per cent cover was determined by dividing the number of inches by the length of the string. The average canopy cover was 7.5 per cent (1.8 to 14.0). Percentages of total canopy cover were: *Artemisia tridentata*, 79.1; *Artemisia frigida*, 2.8; *Artemisia cana*, 6.0; and *Sarcobatus vermiculatus*, 12.1.

Emergent Vegetation

Williams and Marshall (1938) measured emergent cover in culms per linear foot. Low (1945) counted culms or stalks per half square meter quadrats on bulrush, cattail and sedge stands. The method in the present study was a modification of the latter.

Eighty-five quarter-square-meter and 112 square-meter quadrats were made on 10 special study reservoirs. The other 2 did not have appreciable amounts of emergent cover. Plots were selected at random throughout the stands of individual species, and a square of woodlaths was laid over the stands to delimit the quadrat area. The culms within the quadrat were counted. Ranges and averages are listed in Table 4.

Other emergent or semi-aquatic species collected at other reservoirs include: *Alisma gramineum* (narrow-

TABLE 3.—VEGETATIVE COVER AS INDICATED BY NINETY-SEVEN 100-POINT TRANSECTS.

	Musselshell	Carter	McCone	Total	Per cent of total cover
Number of reservoirs measured	4	3	3	10	
Number of points taken	5300	2500	1900	9700	
Points occupied by species:					
Grasses:					
Agropyron smithii (western wheatgrass)	748	626	298	1672	31.1
Bouteloua gracilis (blue grama)	545	127	114	786	14.6
Distichlis stricta (saltgrass)	320	29	314	663	12.3
Stipa comata, S. viridula (needlegrass)	56	33	358	447	8.3
Buchloe dactyloides (buffalograss)		241		241	4.5
Poa secunda (Sandberg bluegrass)		110	86	196	3.6
Poa spp. (bluegrass)	86	9	10	105	2.0
Koeleria cristata (junegrass)		79		79	1.5
Hordeum jubatum (foxtail barley)	31	22	1	54	1.0
Misc. grass	3	102	68	173	3.2
Unidentified grass	65	22	3	90	1.7
Forbs:					
Opuntia polyacantha (prickley pear)	59	5		64	1.2
Artemisia frigida (fringed sage)	37	24		61	1.1
Melilotus officinalis (sweet clover)	110	68	3	181	3.4
Misc. weeds	106	68	13	187	3.5
Others:					
Carex spp.	9	87	167	263	4.9
Juncus balticus			8	8	0.1
Misc. shrubs		32	69	101	1.9
Number of points occupied	2175	1684	1512	5371	99.9
Per cent cover $\frac{\text{points occupied}}{\text{points taken}}$	41.0	67.4	79.6	55.4	

leaf water plantain), *Eleocharis acicularis* (needle spike sedge), *Polygonum amphibium* (water ladysthumb), *P. coccineum* (swamp knotweed), *P. lapathifolium* (dock-leaved ladysthumb), *Rumex mexicanus* (Mexican dock), *R. maritimus* (bristle dock), *Juncus balticus* (wire rush), and *J. torreyi* (bog-rush).

Submerged Vegetation

The following is a list of aquatic plants occurring in the plant collections (species of very limited distributions are not included): *Callitriche hermaphroditica* (water starwort), *Chara* sp. (muskgrass), *Ceratophyllum demersum* (coontail), *Myriophyllum exalbescens* (water milfoil), *Potamogeton pectinatus* (sago pondweed), *P. pusillus* (small pondweed), *P. richardsonii* (clasping-leaf pondweed), *P. zosteriformis* (flat-stem pondweed), *Ranunculus trichophyllus* (water crowfoot), and *Zannichellia palustris* (horned poolmat).

Vegetative Classification of Reservoirs

In 1951 each reservoir was classified

TABLE 4.—QUADRAT MEASUREMENTS OF EMERGENT VEGETATION TAKEN ON 10 RESERVOIRS

Species	No. of quadrats ¼ sq. meter	No. of quadrats 1 sq. meter	Culms per sq. meter range	Culms per sq. meter average*
Eleocharis machrostachya (spike rush)	67		640 – 3948	1996
Scirpus americanus (American bulrush)	18		140 – 820	428
Typha latifolia (cattail)		38	12 – 56	37
Scirpus validus, S. acutus (bulrush)		7	99 – 271	176
Beckmannia syzigachne (sloughgrass)		10	10 – 26	15
Sagittaria cuneata (arrowhead)		21	20 – 67	42
Alisma plantago-aquatica (water plantain)		18	10 – 85	40
Alopecurus aequalis (foxtail)		10	12 – 23	17
Miscellaneous**		8	102 – 278	174
	85	112		

* Numbers are rounded off to the nearest whole number.

** Mixed stands of softstem and alkali bulrush (*Scirpus paludosus*), cattail and American bulrush.

into 1 of 5 types on the basis of emergent and/or adjacent vegetation:

Type I. Sagebrush—grassland. This type affords little or no emergent vegetation. The sagebrush and related plants such as grasses and greasewood extend to the water's edge (Figure 1). Twenty-one of the reservoirs studied were of Type I. The mean age of 15 was 6.5 years.

Type II. Marsh. Cattails and bulrush (hardstem and softstem) afford moderate to dense emergent cover. Spike rush or American bulrush often supply a minor amount of emergent cover (Figure 2). Sixteen of the reservoirs were of Type II. The mean age of 9 was 9.4 years.

Type III. Meadow. This type is predominantly spike rush or American bulrush in moderate to dense emergent stands (Figure 3). Other commonly associated emergents include: smartweeds, American water plantain, arrowhead and sloughgrass. Forty-four of the reservoirs were Type III. The mean age of 28 was 8.4 years.

Type IV. Woody. Willows (*Salix* spp.) and young cottonwoods (*Populus* sp.) usually form a dense stand bordering the shoreline (Figure 4). Six of the reservoirs were of Type IV. The mean age of 5 was 7.0 years.

Type V. Open. Both emergent and adjacent cover are very

sparse or lacking, frequently resulting from overgrazing (Figure 5). Thirty-seven of the reservoirs were of Type V. The mean age of 25 was 8.7 years.

FIGURE 1. Type I reservoir. Sagebrush-grassland.

FIGURE 2. Type II reservoir. Marsh.

FIGURE 3. Type III reservoir. Meadow.

FIGURE 4. Type IV reservoir. Woody.

SPRING AERIAL COUNTS

To determine spring usage, aerial censuses were made during all three years by Wynn Freeman and Missouri Basin Studies personnel. A total of 1,700 waterfowl were observed. The mallard, pintail and blue-winged teal comprised 42.6, 18.0 and 17.5 per cent

FIGURE 5. Type V reservoir. Open.

respectively or 78.1 per cent of 1,066 birds identified to species. Species identified in order of abundance were: mallard, pintail, blue-winged teal, shoveller, gadwall, scaup, baldpate, ruddy, redhead, coot, bufflehead and cinnamon teal.

SUMMER GROUND COUNTS

The twelve species of waterfowl observed during the summer visits were: mallard, gadwall, baldpate, pintail, green-winged teal, blue-winged teal, shoveller, redhead, lesser scaup, bufflehead, ruddy and coot. Pied-billed grebes, eared grebes and American mergansers, seen in small numbers on several occasions, are not included in the totals.

A record was kept of all waterfowl observed during each visit to a reservoir to obtain information on usage and a population index. An attempt was made to avoid duplications throughout a single day, i.e. counting same bird(s) on 2 or more reservoirs. No attempt was made to avoid duplication from one day to the next. The figures include all birds other than non-flying broods (broods are handled separately). In the case of special study reservoirs and several others, visited 2 or more times during monthly trips, the first count was used for the monthly compilations.

A total of 820 ducks was observed in 1949 (1 visit per reservoir), 1698 in 1950 (2.3 visits) and 2663 in 1951 (4 visits).

In 1951 the total population decreased from late May into July. An influx occurred in late July and August. A similar pattern was suggested in 1950.

The three most abundant species, mallard, pintail and blue-winged teal, comprised 86.3, 81.2, and 74.8 per cent of the total summer populations in 1949, 1950 and 1951 respectively.

Only the 1951 data are used to evaluate size and/or vegetative type in relation to waterfowl usage of the reser-

voirs. Waterfowl were observed on 102 (82.3%) of the 124, but records are complete for only 116. Use by size groups and vegetative types is presented in Table 5. Inspection of the table reveals a definite relationship between size and waterfowl numbers observed. Considering size alone it is obvious that on the average, the larger the reservoir the greater the waterfowl use. A single variable classification analysis of variance (Dixon and Massey 1951, Snedecor 1934) of both the means of the size groups and the total numbers in each vegetative type showed these differences were statistically significant at the one per cent level. Considering size by vegetative type the same trend is apparent. Without exception the average usage increased with size within each individual vegetative type. Of the unused 22, twenty-one were 3 acres or less.

Evaluation of usage in relation to vegetative types alone shows considerable differences for the 5 types. The mean use of the Type III reservoirs, 28.2, was considerably above the average use for each of the others, but the differences (Table 5) were not statistically significant at the 5 per cent level by the same test as above. The average

TABLE 5.—TOTAL WATERFOWL OBSERVED (4 VISITS) IN 1951 BY VEGETATIVE TYPES AND SIZE.

		Vegetative Type					No. of res. (size groups)	No. of ducks observ.	Av. ducks (tot. of 4 visits)
		I	II	III	IV	V			
Size Group	1	5* 7** 1.4***	5 12 2.4	13 92 7.1	1 2 2.0	10 31 3.1	34	144	4.2
	2	5 11 2.2	6 39 6.5	13 142 10.9	5 63 12.6	13 92 7.1	42	347	8.3
	3	2 84 42.0	1 13 13.0	9 345 38.3		7 111 15.9	19	553	29.1
	4	2 104 52.0	2 88 44.0	8 448 56.0		3 65 21.7	15	705	47.0
	5		2 141 70.5	1 215 215.0		3 434 144.7	6	790	131.7
No. of res. (veg. type)		14	16	44	6	36	116		
No. of ducks observed		206	293	1242	65	733		2539	
Av. ducks (for total of 4 visits)		14.7	18.3	28.2	10.8	20.4			21.9

* Number of reservoirs of Type I Group 1.

** Total number of ducks observed during summer (4 visits) on the 5 reservoirs.

*** Average number of ducks per reservoir (for total of 4 visits).

usage of Type III reservoirs within each size group is consistently above the average use for all types in each group, but in size groups 2 and 3 it is exceeded by the Type IV and I averages respectively. Type IV reservoirs had the lowest average usage of the 5 types, but none were larger than 3 acres.

Although there appears to be a definite relationship between usage and vegetative type it is not so striking or consistent as the relationship between usage and size.

Considering both size and vegetation together, one would expect from the above analysis that the Type III—Group 5 reservoirs would be used most. This is borne out by the figures in Table 5.

TERRITORIAL PAIRS

Low (1947) referring to the work of Hochbaum (1944) suggests the study of territorial pairs as a measurement of the nesting population in preference to the slower and less accurate nest counts. In 1951 there were 213 territorial pairs of all species observed from May 26 to July 11. Late spring and early summer data from 1949 and 1950 are insufficient for comparisons.

Lone drakes were not included because the single monthly visit to most areas was not considered conclusive in determining territorial drakes. In all probability, some of the pairs moved out of the areas before nesting as evidenced by the presence of scaup pairs in early summer, but the absence of scaup broods in later summer.

NESTING STUDIES

Nesting studies consisted of a single nest search of all Musselshell County ponds in late May, 1950 and 4 concentrated searches on each of the 12 selected reservoirs in May and June of 1951.

Nest searches by rope dragging were patterned after the methods of Bennett (1938) and Sowls (1950). Unless the sagebrush or greasewood cover or the topography prevented it, a 120 ft. rope with 2 tin cans (on the end of a 3 ft. length of heavy wire) attached at 12 ft. intervals was dragged between 2 men. Otherwise the cover was walked in strips or in a zig-zag manner at approximately 30-foot intervals. The perimeters of all reservoirs were searched out to a minimum of 100 yds. Girard (1941) found in western Montana that the average distance from water of 252 mallard nests was 118.67 yds. The average distances from water for 321 shoveller, blue-winged teal, cinnamon teal, baldpate and green-winged teal nests were all less than 100 yds. Bennett's (1938) blue-winged teal nests averaged 41.5 yds. from water and 95.6 per cent were within 220 yds. In 1951 most special study reservoir perimeters were searched to a distance of 200 yards or more from water. The upper drainage bottom and heavier cover was usually covered more intensively. All searches were made between 8:00 A.M. and 12:30 P.M.

Eight nests were found in 1950 and 14 in 1951. Because of the small number, the data for both years are combined in Table 6. Only dabbler nests were found: mallard, pintail, blue-winged teal, green-winged teal and gadwall. Identification for 19 was established by flushing the female; for the other 3 by the use of Broley's (1950) key to the nests of the Anatidae. The average distance to water was 208.3 yds., but 18 (81.8%)

TABLE 6.—NESTING DATA FOR 1950 AND 1951.

	Mallard	B.W.T.	Pintail	G.W.T.	Gadwall	Totals
No. of nests.....	10	6	4	1	1	22
Per cent of nest success.....	70.0	83.3	75.0	100.0	100.0	77.3
Av.number of eggs	9.7(1–17)	8.4(7–11)	6.8(6–7)	9.0	10.0	8.4(1–17)
Per cent egg success.....	58.8	81.0	77.8	100.0	90.0	70.3
Av. distance to water (yds.) ...	319.9	50.5	258.8	42.0	3.0	208.3(1–1760)

were less than 100 yds. The 70.3 per cent egg success was very near to Kalmbach's (1939) hypothetical satisfactory egg hatch of 70 per cent for refuge waterfowl. Girard's (1941) per cent egg hatch varied from 69.7 for the shoveller to 75.2 for the green-winged teal. Per cent egg hatches for the mallard, blue-winged teal, cinnamon teal and baldpate were within these limits. Williams and Marshall (1938) had an average egg hatch of 81.1 per cent (60-85) for 11, 395 gadwall, cinnamon teal, mallard, pintail and shoveller eggs in Utah. Nest success in the present study was 77.3 per cent. Causes of nest destruction were: flooding 2, desertion 1, destroyed by observer 1, and unknown (suspected bullsnake) 1.

Although the information is inadequate for statistical analysis, certain preferences may be indicated. Twelve nests (54.5%) were located in sagebrush-greasewood or western wheatgrass cover and 11 of these were on Type I (Sagebrush-grassland) reservoirs. The remaining 10 were located in 7 different cover types. All vegetative types of reservoirs except IV (Woody) were represented. Sixteen or 72.7 per cent were located near size groups 2 and 3 (1.05 to 5.05 acres). None were discovered near size group 1 (1 acre or less).

BROOD COUNTS

Mallard, gadwall, baldpate, pintail, green-winged teal, blue-winged teal and shoveller broods were seen during the 3 summers. Apparently the reservoirs were not suitable breeding areas for the diving ducks (redhead, ruddy, scaup) present in early summer. Low (1945) indicated that water habitat desirable for redhead nesting was not conditioned by area alone but by its nearness to large permanent bodies of water. Marshes of 10 to 20 acres or larger within a quarter mile of large permanent lakes were most heavily used. Since no area reservoir exceeded 20 acres and none were within 30 miles of large bodies of water, this may represent the limiting factor of redhead and possibly ruddy breeding. Although scaup pairs were common in early summer, none were observed to nest.

Brood observations were made continuously throughout the day from extremes of 5:30 A.M. to 8:00 P.M. It was necessary to search the perimeter of all reservoirs during each visit to flush hiding broods, especially during midday and windy and stormy weather.

The small number of broods on most ponds aided in distinguishing individual broods. In all cases where doubt existed,

a minimum figure was used. The month interval between visits in 1951 was less than the juvenile developmental period for any of the breeding species (Bennett 1938, Hochbaum 1944). In 1951 approximately 25 per cent of the total of 246 broods were considered to have been seen more than once, and undoubtedly some escaped discovery. Thus production figures probably represent a minimum (Table 7).

Broods were classified into 3 age classes: Class I (downy, 0-1/3 grown); Class II (partly feathered, 1/3-2/3 grown); and Class III (wing feathers appearing, 2/3 to full grown). In 1951 ninety broods (47.6%) were seen first as Class I broods; 58 (30.7%) as Class II; and 41 (21.7%) as Class III.

Percent species composition of broods roughly corresponds to the per cent species composition of the total waterfowl counts. The mallard, pintail, and blue-winged teal have been the 3 most important breeders, producing about 75 per cent of the broods observed each summer.

The same statistical analysis was made of the 1951 brood production in relation to size, vegetative type and age of the reservoirs as for waterfowl use. In 1951, sixty-seven (57.8%) of the 116 ponds produced broods. Brood production by size groups and vegetative types is presented in Table 8. The definite relationship between size and number of broods produced is comparable to the trend shown by waterfowl usage. On the average, the larger the reservoir the greater the number of broods produced (Table 8 figures significant at the 1% level). The same trend was apparent, without exception, within each individual vegetative type. Of the 49 reservoirs on which no broods were observed, 43 (87.8%) were 3 acres or less.

Brood production on the 5 vegetative types showed differences, insignificant at the 5 per cent level. The type III (Meadow) reservoirs produced on the average almost one brood per reservoir more than each of the other types. The data are not wholly comparable, however, since 4 of the larger size groups were not represented in 2 of the types (one Type I, three Type IV). The most obvious difference occurs between Type III reservoirs (37.9% of the 116 reservoirs) which produced 53.1 per cent of

TABLE 7.—TOTAL BROODS OBSERVED IN 1951.

	Class I			Class II			Class III			Unclass-	Total
	Broods	Juv.	Av.	Broods	Juv.	Av.	Broods	Juv.	Av.	ified	Broods
Mallard..	36	232	6.4	40(10)*	216	5.4	33(21)	176	5.3	1	79
Gadwall..	3	25	8.3	7	39	5.6					10
Baldpate.	12	77	6.4	5	35	7.0	7(4)	39	5.6		20
Pintail...	14	71	5.1	9(1)	30	3.3	21(7)	74	3.5	5	41
G-w. Teal	3	27	9.0	1	6	6.0	4(1)	19	4.8		7
B-w. Teal	17	109	6.4	3	15	5.0	13(4)	92	7.1		29
Shoveller.	1	4	4.0	2	13	6.5	1(1)	3	3.0		3
Unident..	4	15	3.7	2	5	2.5	1(1)	2	2.0	1	7
	90	560	6.2	69(11)	359	5.2	80(39)	405	5.1	7	196

* Figures in parentheses are broods that were considered to have been observed previously as Class I or Class II broods.

TABLE 8.—TOTAL BROODS PRODUCED BY VEGETATIVE TYPES AND SIZE IN 1951.

		Vegetative Type					No. of res. (size) groups)	Total broods	Average broods reservoir
		I	II	III	IV	V			
Size Group	1	5* 1** 0.2***	5 2 0.4	13 10 0.8	1 1 1.0	10 0 0	34	14	0.4
	2	5 2 0.4	6 3 0.5	13 20 1.5	5 7 1.4	13 5 0.4	42	37	0.9
	3	2 8 4.0	1 1 1.0	9 27 3.0		7 10 1.4	19	46	2.4
	4	2 10 5.0	2 10 5.0	8 40 5.0		3 5 1.7	15	65	4.3
	5		2 10 5.0	1 7 7.0		3 17 5.7	6	34	5.7
No. of res. (veg. type)		14	16	44	6	36	116		
Total broods		21	26	104	8	37		196	
Average broods/res.		1.5	1.6	2.4	1.3	1.0			1.7

* The number of reservoirs of Type I Group 1.

** Total number of individual broods observed during the summer on the 5 reservoirs.

*** Average broods/reservoir produced during entire summer.

the broods, and Type V (Open) (31.0%) which produced only 18.9 per cent of the broods (Table 9). The Type III reservoirs brood production averages were the greatest in every size group except 3 and 4; the Type V reservoirs the least in every size group except 3 and 5. Of the 49 reservoirs on which no broods were observed, 24 (49.0%) were Type V, 11 (22.4%) Type III, 7 (14.3%) Type I, and 7 (14.3%) Type II.

TABLE 9.—BROOD PRODUCTION BY VEGETATIVE TYPES.

Vegetative Type	Per cent of reservoirs	Per cent of broods produced
Type I	12.1	10.7
Type II	13.8	13.3
Type III	37.9	53.1
Type IV	5.2	4.1
Type V	31.0	18.9
	100.0	100.1

Thus it appears that size is a more important factor than vegetative type in determining brood production; a relationship previously noted concerning waterfowl usage.

CONCLUSIONS

It is obvious that the recent construction of a large number of reservoirs has had considerable impact on waterfowl production in eastern Montana. Based on the 1951 production figures, it appears that areas devoid of water habitat in the past produced an

average of almost 2 ducks per square mile. Although the figure is small, the importance is manifest when the large area involved is considered. These facts should certainly be considered in the waterfowl management program.

SUMMARY

1. A study was made of waterfowl production on 124 artificial reservoirs on 3 areas in Musselshell, McCone and Carter counties of eastern Montana during the summers of 1949, 1950 and 1951.

2. The areas are located in semi-arid, sagebrush or grassland prairie regions. Livestock raising, with some dryland farming, is the principal economy. Most ponds are used for livestock watering.

3. One visit was made to each reservoir in 1949, two or more in 1950, and 4 or more in 1951. Twelve representative reservoirs were selected in 1951 for concentrated studies.

4. The average surface acreage for 124 ponds was 3.2 acres. Sixty-five (52.4%) were 2 acres or less. The ponds were grouped into 5 size-groups (Group 1, 0-1.05 acres; Group 2, 1.05-3.05; Group 3, 3.05-5.05; Group 4, 5.05-10.05; and Group 5, 10.05 or larger) for evaluation of waterfowl usage and brood production.

5. Data concerning depth, pH, turbidity, dam construction and seepage were collected.

6. The mean age of 88 reservoirs was 8.2 (1-18) years.

7. The average density of vegetation for ninety-seven 100-point line transects was 55.4 per cent. Western wheatgrass, blue grama, saltgrass, buffalograss, Sandberg bluegrass and needlegrass made up 74.4 per cent of the total ground density. The average canopy cover of forty-three 50-ft. line intercepts was 7.5 per cent. *Artemisia tridentata* made up 79.1 per cent of the total canopy cover. Principal emergent and submerged species are recorded. Ranges and averages of one-quarter and one square meter quadrat measurements on 8 emergent species are listed.

8. The 124 reservoirs were classified into 5 vegetative types on the basis of emergent and/or adjacent vegetation (Type I—Sagebrush-grassland, Type II—Marsh, Type III—Meadow, Type IV—Woody, and Type V—Open), for evaluation of waterfowl usage and brood production.

9. Aerial counts were made each spring. One thousand and sixty-six of the 1700 waterfowl observed were identified to species. The mallard, pintail, and blue-winged teal comprised 78.1 per cent.

10. Twelve species of waterfowl were observed using the reservoirs during summer ground counts. The mallard, pintail and blue-winged teal comprised 86.3, 81.2, and 74.8 per cent of the total summer population in 1949, 1950 and 1951 respectively. The Musselshell area had a greater variety and more evenly distributed species composition than either of the others. Data showed that the total population decreased from late May into July. An influx occurred in late July and August.

11. An evaluation of waterfowl use by size and vegetative type showed that on the average the larger the pond the greater the usage (significant at the 1% level). The Type III reservoirs were used more on the average than the reservoirs of the other types (but not significant at the 5% level).

12. Two hundred thirteen territorial

pairs were observed in 1951 but the data were known to be incomplete.

13. Twenty-two nests, 8 in 1950, 14 in 1951, of 5 species (mallard, pintail, green-winged teal, blue-winged teal and gadwall) were discovered. The average distance to water was 208.3 yds. but 18 (81.8%) were less than 100 yds. Seventy and three-tenths per cent of the eggs and 77.3 per cent of the nests were successful.

14. No species of diving duck was represented by broods. The brood species composition corresponded roughly to the per cent species composition of the total waterfowl counts. The mallard, pintail, and blue-winged teal were the 3 most important breeders, producing about 75 per cent of the broods observed each summer.

15. An evaluation of brood production in relation to size and vegetative type showed that on the average, the larger the reservoir the greater the number of broods produced (significant at the 1% level). Differences in the average brood production between the vegetative types were not significant at the 5 per cent level. The most striking difference in the vegetative types was between Type III reservoirs (37.9% of the 116 reservoirs) which produced 53.1 per cent of the broods, and Type V (31.0%) which produced only 18.9 per cent of the broods. As in waterfowl usage, the relationship between brood production and vegetative type was not as pronounced and striking as the relationship between brood production and size.

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Accepted for publication July 29, 1952.

ROADSIDE DRUMMING COUNTS A SPRING CENSUS METHOD FOR RUFFED GROUSE[1]

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The object of this study was two-fold—to determine population trends and relative abundance of ruffed grouse, and to develop a spring census method by a roadside drumming count. Wellein began the study in 1945 and developed the technique for roadside drumming census. This method with a few modifications has been in use during the past four years, 1949-1952, in six Game Management Areas in northern Minnesota. Information was collected on time and frequency of drumming, radius of audibility, and the effects of weather on the drumming birds. Drumming peaks for each area for each year were determined, and topography and cover types in relation to the number of birds were noted for each route.

Techniques Used

Three representative routes were established in each of the six Game Management Areas, and each route was driven at least three times under good weather conditions during the drumming period. This procedure ensured the finding of the peak of the drumming period for each area. The highest count of drummings for each station was used to calculate the number of males per square mile on the various census routes. Each census route was ten miles in length, or a multiple of ten. The routes were driven between 5 and 8 a.m. Evening routes were not driven due to wind conditions which have a decided effect upon audibility.

Drumming Interval

Four minutes was found to be the average time interval between drummings for a given bird. Therefore, stops of four minutes in length were made at one-mile intervals and all drummings heard were tallied. The same stops were used each trip to help determine the highest count for each station.

Radius of Audibility

A radius of audibility of one-eighth mile, determined as follows, was found to be the most true radius under average morning weather and cover conditions in northern Minnesota. When a drumming bird was located, one man remained at the spot to keep the bird in sight and to raise his arm each time the bird drummed. A second man walked along the road away from the drumming bird and maintained a watch for the raised arm signal. The position where the last drumming was heard, coinciding with the arm signal, indicated the limit of audibility. Several checks were made in three game areas to arrive at an average radius. The extreme radius under ideal weather conditions was found to be three-sixteenths of a mile.

[1] A contribution from Pittman-Robertson Surveys and Investigations Project 11-R, Minnesota Division of Game and Fish.

The one-eighth-mile radius fit conditions and made it possible to distinguish all drummings on average mornings. In general, perfectly still, ideal weather conditions are the exception rather than the rule for most spring mornings.

CALCULATION METHOD

The average number of drummings per ten stops was computed as a basis of population comparison from year to year.

The following formula was used for computing the number of drumming males per square mile:

$$\frac{A}{(1/8^2)\ (3.1416)\ (10)} = T$$

when A = average number of drummings per ten stops, and T = total drumming males per square mile.

A sex ratio based on the previous fall's kill record was used to compute the number of females per square mile. For example, if a sex ratio of one female to 1.2 males was indicated, the number of females per square mile would equal the number of males per square mile $\times \frac{1}{1.2}$.

STUDY OF DRUMMING ACTIVITY, TIME AND FREQUENCY

The four-minute interval was selected after observation on several individual grouse showed that this interval was approximately the average between drummings. Additional work verified it. A typical time interval observation on a grouse is as follows, in minutes: 3 - 4 - 3½ - 5½ - 4 - 4½ - 4 - 4 - 3 - 3½ - 4 - 4½ - 4. Several observations where the birds were seen flying to the drumming log indicate that the birds drum very irregularly for quite some time. The time intervals are short at first and finally settle down to four-minute intervals.

Drumming activity takes place in two main periods—morning and evening. In the morning, drumming begins shortly after 4 a.m., reaches a maximum between 5 and 6 a.m., and then levels out to a plateau between 5 and 10 a.m. After 11 a.m. drumming falls sharply to approximately zero. In the evening, drumming begins after 4 p.m., reaches a peak before 5 p.m., and levels out to a plateau between 5 and 8 p.m. After 8 p.m. it falls sharply to zero.

These observations on periods of drumming activity were made during the low in the grouse population, 1945. Work during the present high of the cycle substantiates the earlier work on time and frequency of drumming activity. More random drumming has been noted during the day and throughout the night during the present high of the cycle. Drumming was found to be more intensive and more easily heard during the early morning from 5 to 8 a.m. than later in the morning. Wind conditions become a problem after 8 a.m. Drum counts were discontinued during the evening periods due to wind conditions, especially after "leafing-out" time.

DRUMMING PEAK

The peak of drumming varies each year according to the time of the spring break up and it varies from south to north with a close correlation to the disappearance of the snow. Seven to fifteen days' difference in the start of drumming was noted in 1951 between north-central and the northern portion of Minnesota. In Area 1, Ely, drumming

intensity was earlier in the Grand Marais area south of the Sawtooth Range than near Ely, due to the sun's rays striking the south-facing slopes of the Sawtooth Range.

In 1952, statewide warm weather made snow conditions more uniform, and the drumming peak was approximately the same for all areas. It is believed that the distances between the Game Management Areas in northern Minnesota are not great enough to make a difference in light intensity. It appears, therefore, that the event of warm bare ground stimulates the start of drumming more than any other factor.

Spring drumming periods have occurred between the dates of April 15 and May 30. In general the drum peaks over the four-year period of this study have been as follows: 1949, April 25 to May 5; 1950, May 5 to May 30; 1951, May 1 to May 20; 1952, April 20 to May 5.

Effects of Weather and Other Disturbances

Weather conditions can have a decided effect upon drumming activity. Rain, thunder storms, and cloudy misty weather, all tend to stop or sharply curb drumming. Clear, still mornings are essential for an accurate drum count. Wind does not effect drumming intensity, but it does cut down on the radius of audibility very rapidly.

Cars and roadgraders disturb most nearby drumming males. Some birds are undisturbed by a car and noise only thirty feet away. Others either cease drumming or extend the time lapse between drummings.

Topography and Cover

Topography and cover types vary along the grouse census routes in each Game Management Area. Area 1, northeastern Minnesota, is mainly a coniferous area with aspen and birch; Area 3, extreme north-central Minnesota, has much bog-type cover with low, flat terrain; Area 4, northwestern Minnesota, is on the edge of the prairies; and, Areas 2, 6 and 7, north-central Minnesota, have a mixed type of topography and cover with a great variety of plant and tree species. It is these central Minnesota areas that have consistently produced the highest drumming counts.

The drum count routes include various mixtures of cover types, from maple - basswood forest to the northern coniferous forest types of spruce and balsam. The highest drum counts were made in the mixed hardwood - coniferous type and the lowest counts in the semi-open bog, tamarack, and mature hardwood stands.

Results of the Counts, 1949-1952

The present high in the ruffed grouse population has occurred during the 1949-1952 period. In the spring of 1952, an average density of 104.6 birds per square mile was tallied as compared with 14.1 birds per square mile during the low of 1945. The number of birds per square mile in 1952 for the several Game Management Areas was as follows: Area 1, 29.9; Area 2, 167.2; Area 3, 74.8; Area 4, 52.2; Area 6, 111; and, Area 7, 148.6. Population statistics for the period 1949-1952 are summarized in Table 1.

Other Work

Some of the best information on

TABLE 1.—MINNESOTA RUFFED GROUSE ROADSIDE DRUMMING COUNT STATISTICS, 1949-1952.

Year	Av. No. Males per sq. mile	Av. No. Females per sq. mi.	Total Birds per sq. mile	Av. No. Drums per Ten Stops	Square Miles Covered	Total Drummings	No. of Stops Made	Drummings per Stop
1949...	32.2	26.8	59.0	16	21.8	362	218	1.6
1950...	36.7	30.5	67.2	18	7.82	298	163	1.8
1951...	50.6	42.1	92.7	24.8	7.82	398	160	2.48
1952...	57.1	47.5	104.6	28	7.78	451	160	2.8

ruffed grouse abundance over a period of years has come from the Cloquet Forest Experimental Station of the University of Minnesota. Data have been gathered there by wildlife students using the King ruffed grouse census method. The population density on the Cloquet Forest, which is located within the drum count area, was 7.5 acres per bird in 1951 and 15.1 acres per bird in 1952, (Magnus, 1951).

SUMMARY

1. Roadside drumming count of ruffed grouse is a satisfactory method of determining population trends and relative abundance of the birds.

2. Roadside drumming count makes it possible to cover a large area with few observers and it is possible to obtain a large number of observations even in a low grouse population.

3. The drumming counts were made on representative routes under good weather conditions from 5 to 8 a.m.

4. The interval between drummings was found to average approximately four minutes and a radius of audibility of one-eighth mile was found to be the most true radius for northern Minnesota cover types.

5. The spring drumming peaks vary somewhat in each area according to the disappearance of the snow, and each year according to the spring season, early or late.

6. The average number of drummings per ten stops has increased from 16 in 1949 to 28 in 1952, and birds per square mile from 59 in 1949 to 104.6 in 1952. The 1949-1952 period appears to be a high in the ruffed grouse population.

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Accepted for publication Aug. 8, 1952.

TESTS OF POCKET GOPHERS GNAWING ELECTRIC CABLES

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Introduction

Rodents of various kinds occasionally gnaw insulation from wires and cause short circuits. Such damage usually occurs on wires located inside buildings or on cables buried underground, although at times tree squirrels become destructive to wires suspended between poles. Pocket gophers (*Thomomys*, *Geomys*, and *Cratogeomys*) are probably the principal offenders responsible for damage to buried cables.

In certain localities pocket gophers have been reported gnawing through conduits and insulation on signal cables along railroads. Cases have been reported where the copper conductors as well as the cable insulation were gnawed away by gophers. Because of these instances, this study was undertaken at the request of W. J. Delehanty of the General Electric Company, to test the ability of pocket gophers (*Thomomys bottae*) to penetrate different types of insulation. Most of the samples used were provided by the General Electric Company, although some (many of which are not illustrated in this article) were furnished by the following: Pacific Telephone and Telegraph Company, Alarm Corporation, Carbon Products Corporation, and Yardley Plastics Company.

Methods

Field testing requires many years, since a cable that is not damaged by gophers until ten years after installation is still considered inadequately insulated. Therefore, only laboratory tests are included in this report. Destruction frequently occurs in the first few months, although damage was recently reported on one that had been buried for five or six years. Cables are expensive to replace, and great inconvenience is caused when the circuits are broken; therefore it is desirable that the cables last almost indefinitely. Laboratory tests do not guarantee that gophers will damage the same types of material under field conditions, or that the insulations not destroyed in the laboratory will be safe when buried in the field. Such tests do demonstrate, however, that the animals apparently have the capabilities of penetrating all non-metallic and soft metallic kinds of armor. The study has proved to be of value to the cable industry, because experience has shown that the materials which were penetrated by gophers in the caged experiments also have been damaged under field conditions.

To test the resistance of various insulating materials to gnawing by pocket gophers, an animal was confined in one part of its cage by blocking the passageway to the remainder with a six-inch section of cable. In some instances, samples were placed so as to allow the animal easy access to both ends of a short tunnel. Usually, however, even though gophers appeared to gnaw

insulation from stationary wires that did not block their passage, the samples were placed so as to confine the animal in one portion of its cage. Gophers thus confined would gnaw on the material much sooner. An ample food supply was available at all times.

RESULTS

Caged gophers were unable to penetrate armor of interlocked galvanized steel, overlapped stainless steel band of .005-inch thickness, and aluminum basket weave. Pieces of 1/4-inch and 1/8-inch hardware-cloth mesh wrapped around cables also effectively repelled gophers. Softer metallic armor of lead and .005-inch thickness of copper, however, did not resist gnawing by gophers (Fig. 1).

There was rapid penetration of all non-metallic armored cables which were made in various types using the following jacket materials: cotton braid with asphaltic saturant, asbestos with asphaltic saturant, 60 per cent natural rubber, polyethylene, polychloroprene,

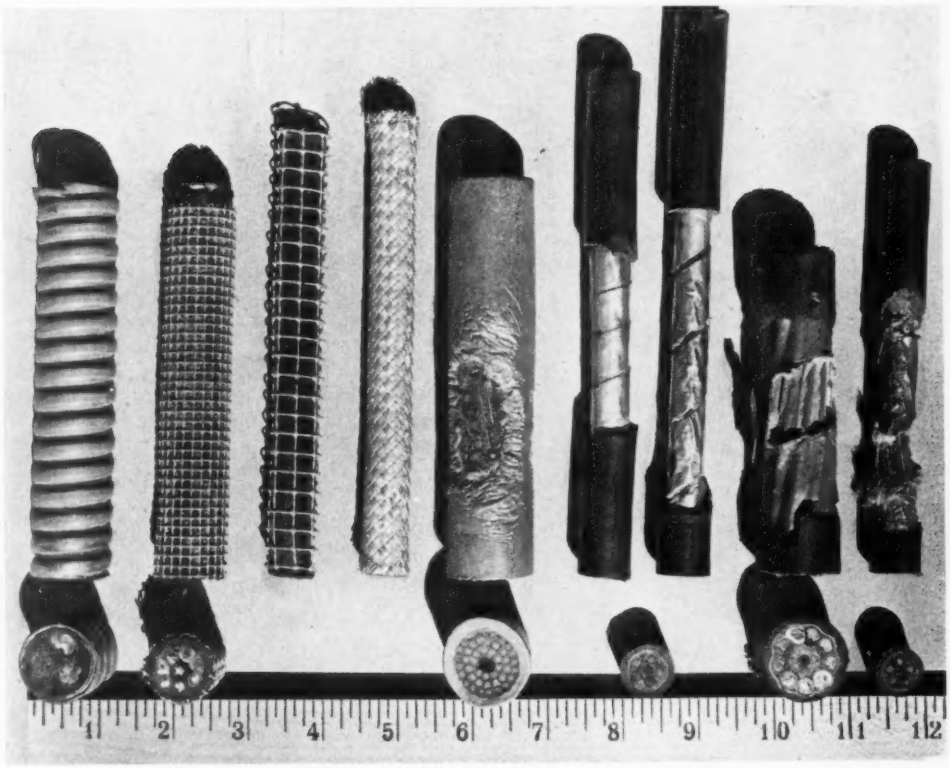

FIG. 1. Caged pocket gophers gnawed into such soft metallic insulating armors as lead (center) and overlapped bands of .005-inch thickness of copper (two on right). The gophers were unable to penetrate (from left to right) interlocked galvanized steel, 1/8-inch and 1/4-inch hardware cloth, aluminum basket weave, and stainless steel band of .005-inch thickness, if overlapped, (fourth from right).

thermoplastic, vinyl, glass braid over silicone, and glass yarn. With spirally wrapped armor of 15-mil soft steel wires, braided in groups of six with cotton yarn to facilitate manufacture, the animals were able to single out individual strands of wire and break them, in addition to spreading the wires apart sufficiently to gnaw the insulation between them, exposing the conductors. Inclusion of poisons or repellents in insulating materials does not appear to be practical. The addition of poisons to the cable would create a hazard to factory employees and installation crews. It is likely that most poisons and repellents would soon leach as a result of moisture in the soil. The author knows of no repellent that would retain sufficient strength to repel gophers after it had been buried underground for several years. Since each gopher must take at least one or more bites before becoming poisoned, some insulation would still be removed. A second gopher might continue working at the same place; and, over a period of years, a succession of animals might take their turn gnawing through a particular section of a cable.

Two milled sheets of thermoplastic compound, one of which contained two parts Goodrite z.i.p. and another that contained one per cent z.a.c.—the bitter-tasting ingredient of z.i.p.—did not deter the gophers. It should be mentioned, however, that Goodrite z.i.p. is effective as a deer and rabbit repellent. Apparently gophers are not repelled by it because they do not eat the insulation, and because they can avoid getting any of the treated material in their mouth while gnawing on the object (Fig. 2). When a gopher was exposed to an insulation of glass yarn, the animal promptly removed the glass material and lined its nest with it.

Discussion

When pocket gophers gnaw on different types of insulation, it appears that the animals exert less pressure in biting small wires one millimeter or less in diameter than they do on larger objects. Apparently gophers can make contact with all four incisors simultaneously only on the larger wires. It seems that the incisors slip either in front or behind small wires when the animals attempt to gnaw them on the long axis. If they attempt to bite across small wires, only one opposing pair of incisors can make contact with the wire at the same time. Possibly, in order to avoid breaking their incisors, animals hesitate to exert much pressure, unless all four incisors are in contact with the object. Also they may be instinctively careful of getting wires or other materials lodged between the upper pair or lower pair of incisors. When malocclusion occurs as the result of a foreign object lodged between the incisors or from some other reason, rodents cannot keep extrusive incisor growth worn away, and the uninterrupted lengthening soon results in the death of the animal. If the incisors are not regularly worn away they continue to grow until the animal dies of starvation, either because of an inability to eat or because the teeth curve back into the mouth cavity and eventually puncture the palate and enter the brain.

Tests were conducted by wrapping cables with wires spaced about 3/16 of an inch apart. As long as the wires could be held in place and not separated by the gophers, the underlying insula-

tion was not damaged. Other tests were conducted using 1/4-and 1/8-inch hardware-cloth mesh as a protective armor. Cables protected in this manner were not damaged. One such test was continued for 33 days, whereas sometimes

FIG. 2. Since the incisors of pocket gophers protrude outside the mouth cavity as shown by this animal, which has its lips closed, the inclusion of poisons and repellents in insulation does not prevent gophers from gnawing on the material.

only a few minutes were required before damage was done to insulation. It appears that if industry could develop an armor which has the characteristics of 3/16-inch hardware-cloth mesh, it would resist pocket-gopher damage. Such an armor would require less material and would be easier to install than heavier cables encased completely in metallic armor. Equipment was not available to measure the force which gophers exert when biting different-sized objects, although such a study is desirable.

Apparently gophers gnaw on unpalatable insulating materials buried underground either to get to the other side of the obstruction without having to go under or over it, or for the purpose of wearing down their rapidly growing incisors. Incisor teeth of all rodents and rabbits continue to grow outward during the entire life of the animal. The phenomenal growth rate of incisors in adult pocket gophers (*Thomomys bottae*) is more than twice as rapid as in all other kinds of rodents studied to date; each upper incisor averages a daily extrusive growth of 0.62 mm. or 9 inches per year and each lower incisor 0.99 mm. or 14 inches a year, or a total annual extrusive growth of 46 inches for all four incisors (W. E. Howard and M. E. Smith, 1952, Jour. Mamm., *33*: 485-487). The average daily rate of growth of each incisor (0.81 mm.) is five times the average growth of each nail (0.16 mm.), which is surprising since the nails are much softer than the incisors (W. E. Howard, Jour. Mamm., in press.). It is not essential for gophers to gnaw on hard objects to keep their incisors worn, however, for they are able to grate the lowers and uppers together to keep the teeth chisel-sharp and also prevent their getting too long.

SUMMARY

Pocket gophers do not attack underground cables because the materials in the cables are attractive or because they have food value. Rather the damage seems to result from an animal's efforts to remove an obstruction to his tunneling activity or merely to wear down rapidly growing incisors. Gophers appear to have the ability to gnaw through non-metallic armored cables and those of soft metallic armor such as lead or .005-inch copper. Inclusion of poisons or repellents in insulations is not practical or effective. Materials that have resisted gopher attack include: steel armor, aluminum basket weave, and hardware-cloth of 1/4- and 1/8-inch mesh wrapped around the outer jackets of experimental samples.

It appears that some form of spaced wiring such as is found in 3/16-inch hardware-cloth mesh or the same degree of spacing of tightly braided wires would make an armor adequate to resist attack. Such a method would require less material, be lighter, and be easier to handle than steel jackets. Although gophers apparently cannot gnaw on small wires, the wires need to be strong enough to prevent breakage if the animal pulls them one at a time.

Accepted for publication September 8, 1952.

CONTROL OF JAPANESE HONEYSUCKLE IN WILDLIFE BORDERS

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Japanese honeysuckle (*Lonicera japonica*) is an introduced woody vine that grows from Florida to Texas, north to Massachusetts and the southern parts of New York, Ohio, and Indiana and west to eastern Kansas. It is particularly abundant in the Southeast where it can be seen along almost any country road covering the banks, fences, and even small trees with a smothering blanket. Though the plant's favorite site is in the open or along the edge of woods, it tolerates some shade, and sometimes persists in woodlands for many years.

In many places, this alien vine is a serious liability, necessitating control measures. Nevertheless, like most vigorous, abundant plants that displace more desirable species, this one has some redeeming values in certain situations. Handley (1945) mentions its use as food by bobwhite quail, turkeys, songbirds, and deer and indicates its special value in this regard during periods of heavy snow. In addition, it provides protective cover to small forms of wildlife the year around. Rainey (1949) also cites its many uses by wildlife in Virginia and suggests that their deer increase may very well have been aided by the winter pasturage provided by abundant honeysuckle. Highway departments use this thrifty plant to stabilize steep embankments.

In general, however, the plant is much more a pest than an asset. Wildlife habitat improvement practices in the Southeast commonly run into competition from honeysuckle. Perennial plantings are primarily made along field edges, fencerows, and along contour ridges through fields. In such situations, honeysuckle finds optimum light conditions, and frequently has little difficulty in gaining the upper hand. In addition, honeysuckle does considerable damage to young trees grown for timber, and becomes a nuisance in landscape plantings, in orchards, and on fences.

Control measures available for use against honeysuckle include burning, grazing, mechanical destruction, and spraying with herbicides. Where a selective job of eradication is not necessary, as along field edges without borders, Handley (*op. cit.*) states that burning is effective in keeping honeysuckle under control. Along junctions of pastures and woods edges livestock will browse the vine and keep it from spreading into the field.

In wildlife borders control of honeysuckle presents the problem of destroying unwanted plants growing among desired ones. Hand cultivation is impractical because of expense and slowness. Nor can disking control honeysuckle which has become established among shrubbery plantings not subject to mowing. Whether periodic mowing and disking of bicolor lespedeza borders will keep honeysuckle from becoming established will be determined in future experiments.

Early in the farm-wildlife investigations at the Patuxent Research Refuge near Laurel, Maryland, it was discovered that Japanese honeysuckle had to be overcome if field borders, rose fences, and contour hedges were to retain site dominance. At the time of planting, grasses and weedy annuals were suppressed by means of heavy mulching but this did not preclude honeysuckle.

Honeysuckle was found to invade the borders both from within and without. Establishment within a border could occur in two ways: dropping of seed by birds and by vegetative propagation—either through remnants of honeysuckle vine surviving after disking or through branches of the vine growing outward from the woods margin. Whatever the source, honeysuckle had established itself in many borders by the third year.

The first attempt to use chemical control of honeysuckle at Patuxent occurred in 1949. In early April, several square yards of a *Lespedeza bicolor* border, infested with honeysuckle, were treated with an aqueous solution (about 0.1%) of 2,4-D acid. This solution was made by dissolving 200 grams of 2,4-D acid powder in 600 cc. of triethanolamine (more than enough to dissolve the 2,4-D). About 750 cc. of solution resulted. Forty cc. of this solution were diluted to 2½ gallons for use with hand sprayer, or the entire 750 cc. were diluted to 50 gallons for use with power sprayer.

At the time of the spray application, honeysuckle had started active growth, and bicolor was still dormant. Upon examination later in the spring and again during the summer it was evident that the honeysuckle had been killed and the bicolor showed no injury. In May and again in June, 1949, honeysuckle along a woods margin bordering a 4-row shrub border was sprayed with the same equipment and same herbicide used earlier in the year on the bicolor. A fairly good kill was obtained, but not without some damage to shrubs in the nearby border due to drift of the spray. The lack of complete kill of honeysuckle and damage to desirable shrubs indicated that earlier spraying dates would be better for treating a woods edge along a border.

Encouraged by the 1949 results, a larger section of the bicolor borders was sprayed in April, 1950. Method of application and herbicide used were the same as in 1949. Spraying was timed to coincide with beginning of honeysuckle growth and before bicolor ended dormancy. Again, honeysuckle was killed and bicolor did not exhibit any signs of damage. Denseness of the bicolor made it difficult to reach all vines with the hand sprayer but surprisingly good coverage and kill were obtained. At Patuxent, new leaves begin to appear on honeysuckle around the first week in April, while bicolor does not start active growth until around the end of April. This seasonal difference in resumption of activity appears to be a significant factor in successful treatment of honeysuckle since vulnerability to 2,4-D is recognized as being generally greatest during active growth.

Addition of a 50-gallon power sprayer permitted expansion of the herbicide program in 1951. It was decided to treat the woods edge along three borders —a total of about 4,000 feet—and also to spray honeysuckle within two bicolor borders. The woods edge was sprayed in

a zone about 10 feet wide with a mixture of 1 gallon each of alkanolamine salt of 2,4-D and butyl ester of 2,4,5-T in 50 gallons of diesel oil—a concentration of the acids of about 1% each. This mixture was selected because of its reported effectiveness by Carleton (1950) upon brush when in the dormant state. Since the spray supposedly works in two ways—getting at living tissue beneath the bark and reaching tissue at base of brush from which sprouts arise—it necessarily had to be high in concentration in a vehicle like diesel oil. The dates of spraying—March 12, 21, and 23—were early enough so that none of the shrubs in the border had started growth. This permitted spraying the woods edge with minimum chance of damage to the borders by drift and vapors. It is believed that spraying in February would have been just as successful with the advantage of a longer period between spraying and start of growth of the border plants.

Results of the woods-edge spraying showed a complete kill of honeysuckle and about 75% kill of greenbriar (*Smilax* sp.) and sumac (*Rhus copallina*). The spread of honeysuckle into the border was halted for that year. Examination this year (1952) shows some sprouting of new vines coming up through the mass of dead plants in certain areas which may require another spraying in 1953. At this stage of the investigation it appears that the woods edge along borders may have to be sprayed with a strong herbicide once every two years.

Control of honeysuckle within the bicolor border was made easier with the power sprayer. Vines received a better coverage than was possible with the hand sprayer. Apparently a heavy coverage of the aqueous solution of 0.1% 2,4-D acid from the power sprayer was safe for bicolor since no damage occurred to the borders.

Only honeysuckle growing within bicolor borders was sprayed in 1952. Up to the time of the writing of this paper (September, 1952) the results have been similar to those of previous sprayings.

It must be understood that herbicide spraying once a year does not necessarily prevent new honeysuckle from appearing. However, observations of borders treated for two years indicate that annual spraying promises to keep bicolor borders from becoming honeysuckle borders.

Spray techniques for eliminating honeysuckle from within shrub borders and rose hedges are now being investigated. These problems may be more difficult to solve since both the honeysuckle and desirable plants start their spring growth at much the same time.

If spraying for honeysuckle control must be added to other expenses of maintaining a wildlife border, the relationship between cost and wildlife production should be of some concern. However, since we do not have an appraisal of the wildlife effects of a good border, an accounting cannot yet be made. Experimental work at Patuxent indicates they honeysuckle can be controlled by properly applied herbicides but it does not show whether or not the practice is economically feasible.

SUMMARY

1. Japanese honeysuckle, an exotic that can be either a pest or an asset in different localities, makes maintenance

of wildlife plantings in the Southeast a difficult problem.

2. A herbicide applied during the winter and strong enough to kill dormant woody plants will stop the spread of honeysuckle from a woods edge for at least two years.

3. A low-percentage 2,4-D water spray applied to honeysuckle growing in bicolor lespedeza borders at a time when honeysuckle is starting growth and bicolor is still dormant will selectively destroy the vine without injuring the border.

4. Studies on control of honeysuckle in multiflora rose, shrub borders, and contour hedges by herbicides are planned for the future.

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Accepted for publication September 22, 1952.

EFFECTS OF STARVATION ON WILD MALLARDS [1]

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The ability to withstand temporary and prolonged periods of food shortage is of great importance to waterfowl in those areas where an abundance of natural foods does not occur. In some areas the amount of food available to waterfowl populations is at such critically low levels that emergency feeding programs and long-term management plans have been adopted in an attempt to alleviate the condition (Gordon, 1950). In other areas the imbalance in natural food resources is less well defined, though the trend appears to be in the direction of ultimate waterfowl food shortages (Wagar, 1946; Colls, 1951).

[1] Olin Industries Incorporated, University of Illinois and the Illinois Natural History Survey cooperating.

Though there is an enormous literature on the subject of undernutrition, relatively few studies have been devoted to its effects on avian species, and none, apparently, to its effects on wild waterfowl. It is the purpose of this paper to present the results of some observations on captive wild waterfowl during periods of starvation and rehabilitation.

The observations reported herein were obtained as a by-product of an investigation of lead poisoning in waterfowl (Jordan and Bellrose, 1951). Experiments were conducted out-of-doors at the Natural History Survey Laboratory located on the Chautauqua National Wildlife Refuge near Havana, Illinois. Wild mallards, *Anas p. platyrhynchos*, were held either in groups of 10 birds each in wire-enclosed pens 15 feet long

and 6 feet wide, or individually in pens 6 feet long and 3 feet wide. All pens contained a supply of running water piped into large metal tanks. The diet of birds from which adequate food was withheld consisted of a mixture of cereal grains, whereas during rehabilitation ducks were fed an unrestricted amount of commercial duck pellets, a balanced, dry mash food.

EFFECTS OF ACUTE STARVATION

In the initial experiment begun on January 23, 1950 a group of 10 adult drakes was fed a total of 11.5 pounds of grain rationed in increasingly reduced amounts over a 29-day period; 4 pounds were fed in the first week, 3 pounds in the second week, 2.5 pounds in the third week, and 2 pounds in the last week. Based upon an intake of 9.72 pounds of grain by the same group of drakes for one week preceeding the experiment, the level of the starvation diet was calculated to be about 28 per cent of "normal." This percentage may be found to vary somewhat from the actual value because food intake of waterfowl proved to be inversely related to air temperature (Jordan unpub. ms.), and in this experiment the average weekly air temperatures varied between a low of 26.1° and a high of 35.6° F, whereas that recorded for the week preceeding the experiment averaged 32.7° F. The effects of the low energy diet on body weights of test birds are shown in Table 1.

The rate of weight loss in the first week when birds consumed more than 40 per cent of a normal amount of food was significantly greater than that in the second week when intake was little more than 30 per cent of normal. This

TABLE 1.—EFFECT OF AN INADEQUATE LEVEL OF FOOD INTAKE ON BODY WEIGHTS OF ADULT DRAKE MALLARDS. FOOD WAS RATIONED IN INCREASINGLY REDUCED AMOUNTS FROM JANUARY 23 TO FEBRUARY 21, 1950.

Bird No.	Body Weights—pounds					Remarks
	Initial	7th Day	14th Day	21st Day	29th Day	
051	2.5	2.3	2.1	1.9	1.6	
052	2.7	2.4	2.2	2.0	1.7	
053	2.9	2.6	2.4	2.2	1.9	
054	2.7	2.4	2.2	1.9	1.5	Died 29th day
055	2.5	2.3	2.1	1.4	1.4	Died 22nd day
056	2.6	2.4	2.2	1.7	1.3	Died 27th day
057	2.8	2.6	2.4	2.1	1.6	
059	3.1	2.8	2.6	2.3	2.2	
548	3.0	2.5	2.3	1.6	1.6	Died 24th day
549	3.4	2.8	2.6	2.3	1.5	Died 28th day
Av. Wt.....	2.82	2.51	2.31	1.94	1.63	
Av. Weekly Wt. Loss—lbs.....		0.31	0.20	0.37	0.31	
Av. Weekly Wt. Loss—per cent..		11.0	7.1	16.0	16.0	

difference may have been caused by a more rapid utilization of deposit fat during the first week. Such fat constitutes the principal fuel reserve of the body and is highly sensitive to caloric demand (Keys *et al.* 1950). The highest rates of weight loss occurred in the third and fourth weeks when the ration was reduced to about 22 per cent of normal. This may have resulted from an accelerated caloric demand upon the musculature and organs of the body.

Critical body weights were reached by the end of the third week and during the fourth week of the experiment. Five drakes succumbed during the fourth week following an average loss of 47.2 per cent of original weight. The five surviving drakes, sacrificed on the 29th day, had lost an average of 35.7 per cent of original body weight. From the degree of activity and alertness exhibited by these birds, however, it seemed likely that they would have recovered if returned to the pens and supplied with food beginning with the 29th day.

Samples of blood were taken from the five surviving drakes and from a sixth individual (No. 054) that died following the extraction of the blood sample. As a check on the experimental group, blood samples were also taken from three normal drakes. The analyses (Table 2) were made by Dr. Paul D. Beamer, College of Veterinary Medicine, University of Illinois. Though the blood of test birds contained fewer red cells than normal, there appeared to be no close correlation between the decline in numbers of red cells and the magnitude of body weight losses shown in Table 1. The red cell count in bird No. 053, for example, revealed only a slight reduction in number of cells, whereas the loss in body weight was 34.5 per cent. Hemoglobin content of blood was even less reliable as an indicator of the poor physical condition of test birds. The appearance of red cells, except for bird No. 054, was of no value in determining the extent of undernutrition. Ash (1914) concluded that both red cells and hemoglobin are

TABLE 2.—BLOOD MORPHOLOGY OF NORMAL DRAKE MALLARDS COMPARED WITH THAT OF DRAKES FED AN INADEQUATE AMOUNT OF FOOD FOR 29 DAYS

Bird No.	Body Weight (lbs.)	Red Blood Cells (per cu. mm.)	Hemoglobin Content (gms. per 100 cc.)	Microscopic Appearance of Blood
Control	2.5	3,410,000	13.0	Normal
"	2.4	———	—	"
"	2.5	3,590,000	14.5	"
051	1.6	2,450,000	11.5	"
052	1.7	2,380,000	12.5	"
053	1.9	3,330,000	14.0	"
054*	1.5	1,950,000	10.0	Polychromatic cells
057	1.6	———	—	Normal
059	2.2	2,950,000	14.0	"

* Died immediately following extraction of blood sample.

particularly resistant to starvation in man and other animals, and Keys *et al.* (1950) pointed out that dehydration during acute starvation may in many cases mask a slight loss in red cells and hemoglobin. For these reasons it seems advisable to place greater confidence in body weight as an indicator of the degree of starvation than in the hemotological changes described in this experiment.

A further test of the effects of acute starvation was made beginning on April 16, 1951. Ten adult drakes and 10 adult hens were penned separately and deprived of access to all food for 25 days. Air temperatures for the period averaged 57.2° F. As shown in Table 3, the percentage of average weight loss in drakes was high for the first week, lower in the second week, high again in the third week, and continued high for the last 4 days.

The pattern of weight loss in hens differed from drakes only in the last 4 days of starvation when the percentage of average weight loss was less. This singular difference in weight loss between drakes and hens is particularly important because of its apparent relationship to the difference in mortality rates. The overall mortality rate in drakes was double that for hens, and in the last 4 days when the great difference in weight losses appeared, the rate of mortality in drakes was three times that in hens (Table 3). This greater resistance to starvation by hens has also be reported, though to a lesser degree, in the game-farm mallard, ring-necked pheasant, *Phasianus colchicus torquatus*, ruffed grouse, *Bonasa umbellus*, and wild turkey, *Meleagris gallopavo*, but not in the bob-white quail, *Colinus virginianus*, or Hungarian partridge, *Perdix perdix*, where hens were found less resistant (Latham, 1947). Kendeigh (1945) found that in English sparrows, *Passer domesticus*, subjected to climatic extremes and deprived of food and water, the survival of males was greater than that for females, but he attributed the difference to the heavier original weight of the males. Following survival studies of other passerine birds and a review of the literature, Kendeigh (*ibid.*, p. 223) concluded that, at all ranges of temperature studied, longer survival periods during starvation ". . . are correlated with increase in percentage of original weight lost at time of death, with decrease in hourly rate at which weight is lost, or with both." It was further stated that in birds tolerating greater weight losses there is a corresponding greater fat storage and lower rate of lipid metabolism.

The greater resistance to starvation in hen mallards, however, did not result from an increase in percentage of original weight lost at the time of death, and a decrease in the calculated rate of hourly weight loss did not occur until late in the experimental period. The high survival rate in hens may, however, have been related to fat storage. Keys *et al.* (1950, p. 171) state that, "It has been universally observed that women withstand semi-starvation better than men", and further, that, "One of the factors contributing to the better resistance of women to starvation may be the larger stores of body fat." Because fat per unit of weight provides more energy than protein, males may be at a disadvantage during starvation. Observations made during experiments reported herewith indicate that hen mallards may have

larger supplies of fat, at least during the breeding season. Beginning about mid-March and extending to about the last week in May, the food intake of non-incubating hens was found to increase until it equalled, then exceeded that of drakes. The food intake of test hens was also found to exceed that of drakes for several days immediately preceeding the experiment. A sampling of body

TABLE 3.—EFFECT OF STARVATION ON BODY WEIGHTS OF ADULT WILD MALLARDS DEPRIVED OF FOOD FOR 25 DAYS, APRIL 16 TO MAY 11, 1951.

Bird No.	Body Weights—pounds					Remarks
	Original	7th Day	14th Day	21st Day	25th Day	
			(DRAKES)			
750	3.0	2.5	2.1	1.8	1.4	Died 25th day
797	2.8	2.3	2.1	1.7	1.2	Died 25th day
816	2.8	2.4	2.1	1.5	1.3	Died 24th day
836	2.7	2.2	1.7	1.3[p]	1.3[p]	Died 18th day
840	3.0	2.3	2.0	1.5	1.4	Died 25th day
883	2.6	2.2	1.7	1.3[p]	1.3[p]	Died 18th day
889	3.0	2.5	2.3	2.0	1.9	
900	3.2	2.6	2.3	2.0	1.4	Died 26th day
902	2.8	2.4	2.1	1.8	1.4	
920	3.2	2.7	2.3	1.9	1.5	Died 24th day
Av. Wt.....	2.91	2.41	2.07	1.68	1.41	
Av. Weekly Wt. Loss—lbs.....		0.50	0.34	0.39	0.34*	
Av. Weekly Wt. Loss—%		17.2	14.1	18.8	19.1*	
			(HENS)			
522	2.7	2.2	1.9	1.4	1.1	Died 24th day
524	2.4	2.0	1.7	1.1[p]	1.1[p]	Died 21st day
525	2.6	2.2	1.9	1.6	1.4	
532	2.4	2.0	1.7	1.5	1.1	
609	2.4	1.8	1.1[p]	1.1[p]	1.1[p]	Died 12th day
610	2.5	2.0	1.8	1.5	1.4	
618	2.7	2.1	1.8	1.4	1.2	Died 24th day
634	2.7	2.3	2.0	1.7	1.6	
635	2.5	2.1	1.8	1.6	1.5	
637	2.4	2.0	1.7	1.5	1.4	
Av. Wt.....	2.53	2.07	1.74	1.44	1.29	
Av. Weekly Wt. Loss—lbs.....		0.46	0.33	0.33*	0.18*	
Av. Weekly Wt. Loss—%		18.2	15.9	18.2*	11.8*	

[p]—Post mortem weight.

*—Average of weight losses includes only birds alive during preceeding week.

weights revealed that in a period of 18 days before fasting, hens gained an average of 0.16 pound, whereas drakes gained only 0.04 pound. It is likely that a large part of the increase in body weight following higher food intake was in the form of deposit fat. If such is the case, it is also likely that hens entering the starvation period on April 16 would have had ample opportunity to increase fat stores. Thus, hens may have had proportionately greater reserves of energy to draw upon during the foodless period. It is not known whether this sex-related survival differential is also evident outside the breeding season.

The decrease in rate of weight loss in the last week suggests that some physiological factor was operating in hens but not in drakes, or at least not to the same extent. An abnormal decrease in the metabolic rate of hens may have been responsible. Starvation is known to result in decreased rates of metabolism in man (Keys *et al.* 1950) and in ring doves (Benedict and Riddle, 1929). Kendeigh (1934) observed that the body temperature of passerine birds declined under similar conditions. Changes such as these generally result in a reduced caloric demand and a reduction in rate of weight loss.

Critical body weights in drakes were reached during the third week and two birds succumbed on the 18th day. A total of five drakes died on the 24th and 25th days and one additional bird died on the 26th day. Only two out of 10 drakes survived the treatment. The amount of original body weight lost by the survivors averaged 43.1 per cent, whereas in those that died the loss was 53.3 per cent.

In general, critical body weights in hens were not reached until the third week of starvation. By the 25th day, however, only four hens had died. At the time of death these birds had lost an average of 56.1 per cent of original weight, including a maximum loss of 59.2 per cent. The six survivors lost an average of 44.4 per cent of gross weight. One individual survived a loss of 54.2 per cent of its original weight of 2.4 pounds.

Studies by Kendeigh (1945) have shown that the amount of body weight lost by English sparrows during starvation is greatest at air temperatures between 44.5° and 74.2° F., the range in which maximum utilization of body fat was found to occur. From results of the present study it is apparent that this relationship of air temperature to body weight loss may also apply to wild mallards. Thus, the average body weight loss of five drakes dying from starvation in the month of February was 47.2 per cent when air temperatures during the experiment averaged 29.8° F.; that of eight drakes dying in May was 53.3 per cent when temperatures averaged 57.2° F.; and that of three drakes dying in July was 57.7 per cent when temperatures averaged 71.5° F. The average of post mortem weights within each of the three groups was 1.46, 1.36, and 1.10 pounds, respectively.

Weights of some of the principal organs in mallards succumbing to the effects of controlled starvation revealed differences in the resistance of these organs to weight losses even though the number of test birds was small. In two adult males that lost an average of 48.1 per cent of gross body weight the calculated loss of weight in the liver, kidneys, and heart averaged 69.4, 26.8 and 36.7

per cent respectively. Calculations were based upon weights of organs from an equal number of normal birds whose body weights closely approximated those of the test birds before starvation.

The calculated loss of weight in the liver, kidneys, and heart of four hens that had lost an average of 46.4 per cent of original weight averaged 56.6, 14.5 and 38.7 per cent, respectively. Thus, both the liver and kidneys of starved hens appeared to be more resistant to atrophy than those in drakes. In both sexes the loss of weight was greatest in the liver, and on a proportionate basis exceeded the loss in gross body weight. The kidneys appeared to be most resistant to atrophy. In both sexes the gall bladders were enlarged to nearly three times their normal weight of 0.4 gram. The intestines appeared to be greatly atrophied. The gonads of birds dying during the breeding season were largely undeveloped.

REHABILITATION

It was thought that the rate at which mallards recovered from the effects of acute starvation would provide an objective measure of the extent of previous damage to the functions of various organs and tissues. In order to test this, two drakes and six hens (Table 3) were fed an unrestricted amount of commercial duck pellets for 28 days immediately following a 25-day period of starvation. Food intake was measured at least twice per week and weights of birds were taken weekly.

By the end of the first week of rehabilitation, drakes had recovered 80 per cent and hens 83.6 per cent of the total weight lost during starvation. By the end of the 14th day, average weights were nearly equal to those at the beginning of fasting. At the end of 28 days all birds were in excellent health and none showed objective symptoms of previous functional damage. When released from the pens after an interval of 5 months all birds were in good weight and no latent effects of starvation were noted.

For the first 3 weeks of rehabilitation the average weekly food intake of test birds exceeded that of 30 normal drakes and hens by 178, 146 and 54 per cent, respectively. In the fourth week food intake fell off to a level slightly below that of normal.

It is apparent from these and other observations that mallards can recover from acute starvation if food demands are immediately satisfied and the diet is composed of items that are easily digestible. In regard to human starvation, Zimmer, Weill, and Dubois (quoted by Keys *et al.*, 1950, p. 105) observed that, contrary to general belief, "there is no state, except the final coma, where the disease is irreversible." This view seems equally applicable to mallards, as judged from these experiments.

SUMMARY AND CONCLUSIONS

Acute starvation in captive wild mallards was accompanied by a high rate of body weight loss. Air temperature influenced the extent of weight losses. In drakes that succumbed, the loss of original weight during winter weather averaged between 45 and 50 per cent; during the milder temperatures of spring the loss was between 50 and 55 per cent; and during summer it averaged between 55 and 60 per cent. Comparable data on weight losses in hens that succumbed were obtained only

for the spring season. During this period the percentage of weight loss in hens was slightly less than that in drakes.

The weekly rate of weight loss in hens appeared to alternately rise and fall beginning with the first week and ending with the fourth week. The pattern was similar for drakes except that the high weight loss of the third week continued into the fourth week.

Critical body weights in both sexes were reached during the third and fourth weeks of acute starvation, and the frequency of mortalities was greatest during the fourth week.

The mortality rate in drakes was double that in hens during the spring breeding season. This may be related to a differential ability of the sexes to store fat, which provides more energy per unit of weight during catabolism than does protein; it may also be related to different rates of metabolism between the sexes during the stresses of starvation.

Examination of the liver, kidneys, and heart of starved birds revealed that the kidneys were most resistant to atrophy. The weight lost by the liver was proportionately greater than the body weight loss, and that lost by the heart, proportionately less.

When supplied with food, both sexes of wild mallards recovered from losses of original body weight averaging about 44 per cent. Objective symptoms of functional damage to tissues were not observed in birds that recovered from acute starvation.

Birds suffering from starvation under the hazardous conditions in nature could not be expected to survive for as long as captive birds; they would also be less likely to show the same high rate of recovery. It is unlikely, however, that even two weeks of complete abstinence from food would be fatal to mallards in nature during normal winter weather. Beyond this, mortality rates would probably rise sharply, and if extended to one month, heavy losses could be expected.

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Accepted for publication September 22, 1952.

COMMERCIAL CARP REMOVAL AT LAKE MATTAMUSKEET, NORTH CAROLINA

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Lake Mattamuskeet is famous as a National Wildlife Refuge for a wintering concentration of swans, Canada geese and ducks. The 50,000-acre lake is located in Hyde County, North Carolina, seven miles north of Pamlico Sound. Prior to 1915 the lake was an open body of water with no obstructions to mar the surface. The marsh was limited to a narrow band of low flats on the south shore. There was only one small outlet canal draining this vast area.

In 1915 the lake was purchased by a stock company and the largest pumping plant in the world, at that time, was installed. The lake was drained and approximately 20,000 acres were reclaimed for farm lands. Except for short periods, these lands were cultivated until the fall of 1932, when the lake refilled after financial failure of the drainage project.

On October 30, 1934 the Federal Government purchased the lake as a wintering ground for migratory waterfowl. After the refuge was established improvements were begun to manage the area for the purpose desired. More canals were constructed to secure drainage by gravity, not only for the purpose of influencing plant life in the marsh, but also to assist crop production on adjacent private farm lands. An earthen causeway, with five bridges, constructed in 1941-42, more or less divides the lake in halves.

At present, levels are controlled by gates on six canals draining into Pamlico Sound. The lake receives no creek or river drainage, being fed by runoff and agricultural drainage from the surrounding watershed. The open water consists of approximately 30,000 acres, bordered by 20,000 acres of marsh and upland. It is the practice to lower the lake water level during the growing season to expose shorelines as early in the spring as possible for proper growth of native emergent waterfowl food-plants. The number of waterfowl utilizing the area has increased substantially as a result of this drawdown.

Until 1949 the lake water was so turbid that submerged aquatic plants could not exist. Secchi disc visibility in the lake proper was approximately six inches in waters that averaged three feet deep. The salt content of the open lake for the past five years averaged 875 p.p.m. chlorides, or 2.5% sea strength. After the first agricultural drainage the fish population naturally was reduced to a minimum; but, subsequent to the 1932 water rise, there developed a tremendous population of largemouth bass, crappie and white perch, which provided excellent sport-fishing. Since 1937 the lake fishery

[1] Appreciation is expressed to W. P. Baldwin, U. S. Fish and Wildlife Service, for assistance in the preparation of this article.

changed from a predominantly largemouth bass and crappie population to one in which perch and finally carp were dominant. Sport-fishing declined accordingly. Data supporting this trend were collected by the writer and interpreted by Holloway (1948).

THE ROLE OF THE CARP

Since Mattamuskeet is a wintering ground for thousands of waterfowl, a large quantity of natural waterfowl foodplants is needed to carry the birds through the winter. However, the 30,000 acres of open water supported practically no submerged aquatics. A constant six-inch Secchi disc visibility precluded the development of such aquatics. It was thought feeding carp were responsible for the turbid condition.

Observations during the past six years indicated that the carp also were destroying large quantities of marginal marsh vegetation submerged after summer rains. To reduce such depredation and to increase water clarity, a stepped-up program of carp removal was encouraged. Attempts were made to locate a market that would be profitable to local commercial fishermen. One interested person built several ponds near Winston Salem, N. C., during 1948, securing carp from Lake Mattamuskeet for stocking purposes. He then sold permits to local sport-fishermen. It is known that this project yielded a good income to the owner. Construction of carp ponds at other points in the state increased—all with good success. At present (1952) it is estimated there are in North Carolina 150 ponds which frequently restock rough-fish from Mattamuskeet through 20 to 25 individually-owned tank-trucks.

THE REMOVAL OF CARP

The problem of carp reduction in such a vast lake was approached with some trepidation. Local misguided opposition, state restrictions against seining lake waters, and a degree of administrative apathy had to be overcome before fishing could be started. The first attempts with fyke-nets in the canals, starting in 1940, did not yield outstanding results. The problem was complex, in that it was desired (1) to stop the annual migration of adult carp into the lake without halting the spring run of white perch, (2) to reduce the present adult rough fish population in the lake, and (3) to reduce young carp that would continually develop from lake spawning.

STOPPING THE ANNUAL MIGRATION INTO THE LAKE

Lake Mattamuskeet drains into tidal Pamlico Sound through six water-control structures. Principal spring migration of carp and white perch occurs through three of these canals. The peak of the perch migration is in April; that of carp in May. This period coincides with maximum discharge of lake waters to favor waterfowl marsh management and local agriculture. Both species easily entered the lake while the structures were open for drainage. The problem was to modify the structures to permit water passage and white perch entrance but to halt adult carp. Screening of wire failed because of rapid clogging by debris and silt. The water quality also makes metal barriers short-lived. An obvious answer was a weir of wooden construction. On the

"Headquarters-Canal" a successful barricade was developed which passes perch but stops adult carp. It also serves as a trap for lake carp moving through the canals from one section of the lake to another. The weir consists of one continuous slat barricade, with a slat funnel-trap attached, to impound the carp within a two-mile section of a 90-foot-wide canal.

The weir is built of cypress in the following manner. Pilings, 4″ x 6″, are jetted into firm bottom of the canal to support the structure. Then, 2″ x 6″ timbers are notched to allow 1″ x 4″ slats to pass through slots on a two-inch spacing. To keep the slats on the proper spacing and in line, two notched timbers are required, one about two feet above the water line and one near the bottom of the canal, or approximately six feet apart, depending on the water depth. The timbers are bolted to the piling, and the slats are fitted in the top slot, driven through the lower slot into the canal bottom about four feet (or down to solid soil). The portion of the structure where the ends connect with the shore should be riprapped to keep the carp from boring under the structure. The slats are nailed to the top timber only, to permit easy removal of broken slats, and 2″ x 6″ braces are driven into the bottom and bolted to both sides of the barricade. A two-foot wide walkway is attached to one side, furnishing easy access for cleaning debris from the structure. The width of the weir opening is about twelve inches or smaller, according to the size of the impoundment desired and the size of the fish being trapped. A deflector board is attached in the throat of the weir to guide the fish into the impoundment. The structure was constructed by the Fish and Wildlife Service with the North Carolina Wildlife Resources Commission cooperating.

Three periods of fyke netting inside the weirs since 1951 has indicated that they are stopping large carp, gar, catfish and bowfins but passing most game fish. To perfect this phase of management it is desired to construct weirs on the other five outlet canals.

REMOVING THE CARP POPULATION

Adult carp removal was started during 1940, in a small way, by the use of pound or fyke nets located only in the canals. This practice was continued until 1949, with no apparent reduction in the carp population. During the fall of 1949 fishermen were encouraged to convert to drag seines, under strict supervision of refuge personnel. Seining sites free of snags were located and permits assigned to groups of commercial fishermen. It was pointed out to them that baiting of seining sites with grain would improve their catch of carp and catfish. To stimulate this practice the refuge supplied surplus corn for trial seining. This method proved so successful that the fishermen began purchasing their own bait. We have continued to furnish some surplus corn and beans each spring to encourage the removal of as many carp as possible before the onset of the spawning season. Catches at this time are usually small and would not otherwise be economically feasible without this subsidization. Bait for carp and catfish also included soybeans, cottonseed cake, and chicken scratchfeed which attracted as well as corn. Baited spots do not seem to attract game fish. In operating, a lapse

of approximately five to ten hours is allowed after the site is baited to permit carp to congregate. A drag net then is laid out by boat around the baited area and the net pulled in to shore. When this method was first used from one to seven tons of carp were captured in single hauls of a three-hundred-yard seine. The best netting periods have been February to April and September to October. No netting is permitted during the December - January waterfowl hunting season. Daytime seining during cold weather has been successful, but in the summer seining is limited mostly to late afternoons and early mornings.

The carp are kept in good condition while in holding nets with 1″ bar, twenty to thirty feet in diameter and approximately eight feet deep. This type of pound was found to be far more efficient than a holding pen built of wood palings, since the fish did not bruise themselves in their attempts to escape. Transportation by tank-truck for several hundred miles was found feasible during cold weather by the use of aerated tanks similar to those employed by fish-hatcheries. For hot-weather shipment successful transportation was possible by loading the tanks in later afternoon, adding another pump (and sometimes ice), and traveling at night.

REDUCTION OF YOUNG CARP

The seines have been catching sizable quantities of fingerling carp, presumably recently lake-hatched. These are too small for the holding pounds but are often placed directly into the tank trucks. It is felt that additional control of small carp will result from extensive recent stocking of predatory game fish.

EFFECTS OF CARP REMOVAL

The Mattamuskeet carp fishing has improved local economics, physical conditions in the lake affecting the flora, and possibly the sport fishing within the period of the described activity. Over 1,600,000 pounds of carp and 95,000 pounds of catfish have been removed from Lake Mattamuskeet principally for live-sale to North Carolina upland fish ponds.

Below is the catch by years, tabulated from the most reliable figures available:

Year	Carp (pounds)	Catfish (pounds)	Value*
1945	26,341	1,897	$ 2,405.33
1946	6,320	255	543.10
1947	25,753	2,233	2,089.51
1948	54,054	3,459	4,843.17
1949	110,086	13,278	10,798.58
1950	360,012	12,800	30,720.96
1951	745,870	43,831	66,244.25
1952**	367,166	17,658	32,021.98
TOTALS	1,695,602	95,411	$149,666.88

* Gross sale value to commercial fishermen
** Total only to July 31, 1952

In addition to the "commercial" value received by the seiners of Hyde and Dare Counties, North Carolina, this industry has proven remunerative to the truckers and pond owners. The average sport fishing fee for these rough fish is $1.50 for half-day fishing, with a catch limited to ten pounds.

While the economic effect has been locally worthwhile, the effect on the lake management has been even better than anticipated. Secchi disc visibility of lake water was only six inches up to 1948. Coincidental with the last four years cumulative removal of over 1,500,000 pounds of carp, a gradual improve-

ment in water clarity has been obvious, and visibility in much of the shallow lake has increased to three and four feet in depth (1952). It is the opinion of Service biologists familiar with local ecology (unpublished F.W.S. reports by W. P. Baldwin, *et al*) that carp removal is responsible for this improvement.[2]

The immediate result of increased water clarity has been the volunteering of at least 7,500 acres of muskgrass (Characeae) in 1951, and an additional 7,500 acres in 1952, making a 15,000-acre increase in the two-year period. This past summer bushy pondweed (*Naias*) and other desirable pondweeds have appeared, and additional species are being introduced. Damage to shoreline emergents also has decreased. It is assumed that these desirable waterfowl food plants will increase as long as a carp removal program continues, with a consequent marked effect on the size and composition of future waterfowl populations at Mattamuskeet National Wildlife Refuge.

In comparing these results with those in other parts of the country there might be reasonable doubt that this degree of carp reduction could accomplish what is claimed. Perhaps Mattamuskeet results are better understood when one considers the following factors: (1) Earliest and most extensive plant invasion appeared east of the dividing causeway, where the first and greatest carp removal occurred. (2) The new outlet weirs permitted lake removal of carp from populations not replenished by migration from Pamlico Sound. (3) Maximum summer drawdown during 1949-51 resulted in minimum water acreage of 20,000 acres. On the basis of this minimal acreage, the 1,215,968 pounds of carp removed in 1949-51 (the "critical" period leading to wholesale invasion by submerged plants) was about 60 pounds per acre, or 37 pounds for the peak year of 1951.

Possibly the total removal of 1,791,013 pounds of rough fish has permitted a better spawning increase of game fish. According to data collected by Ancil D. Holloway, Service fishery biologist, (unpublished Service report) the 1951 condition factors of game fish showed an improvement and reproduction of bass was found for the first time in many years. A vigorous stocking program also has been instituted. During 1949 - 1952 a total of 1,244,500 largemouth bass fry, 680,000 rock-fish fry, and 160,000 bluegill bream have been stocked.

Based on nearly 100 percent creel census, it has been determined (since the carp removal and the restocking of game fish programs began) that the take of game fish by sport fishermen has gradually increased by 1952 to a figure 75 per cent over previous years. Due to the clarity of the lake waters there are large areas suitable for game fish spawning and should the reproduction of these species reach the point expected, the restocking program will cease.

[2] Editor's note: On the basis of experience reported elsewhere, it is doubtful that the removal of less than 25 pounds of carp per acre in any year can be assumed, without more data, to have reduced a carp population sufficient to change the environment. The reduced turbidity and increased plant growth may have been the result of some other unrecorded factors or may be the result of the carp removal. The changes and operations merit recording and it will be interesting to observe further results of the program.—K. D. CARLANDER.

SUMMARY

1. Lake Mattamuskeet, N. C., embraces some 30,000 acres of open water and 20,000 acres of marsh and administrative upland, all serving as a National Wildlife Refuge, principally for waterfowl.

2. Between 1915 and 1932 the lake was drained for agricultural use, terminating in economic failure. Upon refilling, the lake developed a tremendous game-fish population. Species domination gradually passed from largemouth bass to carp, and sport-fishing declined.

3. Feeding action by carp was believed to be a major cause of the high turbidity in the lake proper, which prevented the existence of desired submerged waterfowl food-plants. Carp feeding was observed to be the cause of widespread destruction to marginal marsh plants.

4. To improve waterfowl habitat a program of carp removal was commenced. A wooden canal weir is described that was successful in passing white perch but stopping adult carp migrating into the lake.

5. An even more successful system of hauling-seining on baited spots in the lake is described.

6. An estimated 150 inland North Carolina fish ponds have been constructed or renovated primarily to use the Mattamuskeet source of rough fish, supplied through a transportation service of about two dozen independent tank-trucks.

7. The removal of over 1,600,000 pounds of carp and 95,000 pounds of catfish from the lake, has resulted in the Secchi-disc visibility gradually increasing from six inches (1948) to three and four feet (1952).

8. Desirable submerged waterfowl food-plants have invaded 15,000 acres of the formerly barren lake bottom, and the spread continues. Carp-destruction of shoreline emergents has been reduced. This new and large supply of waterfowl food undoubtedly will influence future populations and movements of waterfowl in eastern North Carolina.

9. Sport-fishing, which is secondary to waterfowl food production, already has improved, and has been implemented by a restocking program.

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Accepted for publication October 17, 1952.

NOTES ON BIGHORN FOOD IN THE SONORAN ZONE

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Great interest is being shown by conservationists in the restoration of the desert varieties of bighorn sheep (*Ovis canadensis* ssp.). The results of much work already done are not generally available, hence it appears to be of value to record data on bighorn food even though it is far from complete.

Before presenting our Arizona list it seems appropriate to briefly review some of the pertinent literature from adjacent areas. Sheldon (1925) of the sheep of Chihuahua, Mexico, stated, "Their food included a very large variety of desert vegetation, including cactus and its fruit. . . . . Like all other sheep of the southern deserts, including Texas and Arizona, grass of any variety formed so small a percentage of their food that in most cases it was eaten only incidentally." In 1916 Merriam reported as follows upon the stomach contents of a seven-year-old ram killed by Charles Sheldon in the Rosario Mountains of extreme northwestern Sonora, Mexico. "From about a quart of coarsely chewed vegetable fragments the following plants were identified by Vernon Bailey and Paul C. Standley: Ground Cherry (*Physalis*)—many seeds and a few husks; Joint-fir (Popotillo of the Mexicans, *Ephedra*)—two seeds and stems; Evening primrose (*Anagra*)—one woody capsule; Mallow (*Sphaeralcea*)—a few seeds; Brittle-bush (*Encelia*, two sp.)—stems, seeds, and heads common; Hosackia (*Lotus*)—one seed capsule; Spurge (*Croton*)—three seeds; Buckwheat bush (*Eriogonum*)—stems common; Bedstraw (*Galium*)—a few leaves and stems; Spiny bush (*Krameria*)—stems common; Iron tree (*Olneya tesota*)—leaves and stems common; Lichens—a few bits; Grass—no trace that Professor Hitchcock, the grass expert, could detect. More than half of the stomach contents is unidentifiable." In his study of the Texas sheep Bailey (1928) recorded that, "The sheep are especially fond of the browse of mountain mahogany, syringa, *Ceanothus*, and other common shrubs, and feed to a great extent on the smaller plants, and probably to some slight extent on grasses." Hornaday (1908) found the following plants in the stomach of a ram from the Pinacate Mountains of Sonora, Mexico: "galleta grass; palo verde (*Parkinsonia torreyana*); white brittle bush, flower stalks only (*Encelia farinosa*); "torote prieto"; *Terebinthus microphylla* and *Sphaeralcea*." Mearns (1907) reports that the sheep at Tinajas Altas in the Gila Mountains of Yuma County, Arizona feed in February "largely upon a *Cylindropuntia* cactus." Halloran and Kennedy (1949) listed thirty-three plants utilized by bighorn in southern New Mexico. In their comprehensive review of the literature Martin, Zim and Nelson (1951) tallied 17 principal food plants for New Mexico, five for Nevada, and seven, including grasses, for California.

We list 52 plants fed upon by bighorns. These observations were made by

Fish and Wildlife Service personnel over a period of five years on the Kofa Game Range in Yuma County, Arizona. Preferred foods are followed by asterisks. Otherwise the order of listing has no significance as far as food preference is concerned, but follows Kearney and Peebles (1951). Following the name of each plant we have included notations as to the season of known use. These observations are sight records taken at random by administrative personnel and do not represent a full-time study. The necessary plant identifications were supplied by Dr. K. F. Parker, Botany Department, University of Arizona.

Ephedra nevadensis * Sp Su F W
Typha sp. Sp
Bromus arizonicus Su
Festuca octoflora W
Poa bigelovii W
Muhlenbergia porteri * Su
Aristida parishii Su
Hilaria rigida * Sp W
Hilaria jamesii Sp
Bouteloua trifida F
Bouteloua curtipendula * Su F
Phalaris caroliniana Sp
Agave desertii * Sp Su
Quercus turbinella Su F
Eriogonum inflatum Su
Eriogonum deflexum Su
Lepidium lasiocarpum F
Lesquerella gordoni Su
Calliandra eriophylla * Sp Su F W
Acacia greggi * Su
Acacia constricta Su
Prosopis juliflora * Sp Su W
Krameria grayi * Sp Su F
Cercidium microphyllum * Su
Cercidium floridum * Su
Lotus rigidus Su
Olneya tesota Su F W
Erodium texanum F
Polygala macradenia Sp
Bernardia incana Sp
Simmondsia chinensis * Sp Su F W
Rhus trilobata Sp
Gayoides crispum F
Sphaeralcea coulteri F
Sphaeralcea ambigua * Su F
Sphaeralcea ambigua var. *rosacea* F
Carnegiea gigantea * Su
Opuntia engelmanni * Su
Opuntia bigelovii F
Fouquieria splendens Sp Su
Asclepias albicans W
Verbena gooddingii Su
Teucrium glandulosum Sp
Salazaria mexicana Su
Hyptis emoryi F
Lycium andersonii * W
Plantago purshii var. *picta* * W
Plantago insularis * W
Baccharis sp. Sp
Franseria dumosa * Sp W
Franseria ambrosioides W
Encelia farinosa * Sp Su F W

In addition to the sight records listed above we present the results of three stomach analyses of sheep from Yuma County. A mature ram, illegally killed in the Sierra Pinta Mountains in December of 1947 contained, according to C. C. Sperry, F. W. S., "at least 90% joint fir (*Ephedra*); balance of material included mistletoe, skeletons of deciduous leaves, and fruits of a solanaceous plant." Again, on 4/29/48 Sperry reported on a mature ram that had apparently died of old age in the Kofa Mountains sometime during the summer of 1947: "The bighorn sample was composed of stems of joint fir (*Ephedra*) 70%; Coffee-berry (*Simmondsia*) 20%; twigs of another shrub (*Cercocarpus* ?); Grass—trace." A young ram killed by

car in March, 1952 in Telegraph Pass in the Gila Mountains was also reported upon by Sperry with the cooperation of A. C. Martin. The stomach contained: "Cactus (leaves and spines) 5%; grasses 5%; a few seeds of a Legume and *Physalis*, trace; fruits of brittle-bush (*Encelia farinosa*) 10%; woody materials, probably forbs—maybe *Encelia*, 80%."

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Accepted for publication October 27, 1952.

GROWTH RATE OF THE RACCOON FETUS

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Time of breeding and parturition are important in life history studies although usually they are difficult to determine accurately in the wild.

Vaginal smears in some species can be used to give a fairly accurate breeding date, but this procedure usually requires handling the animals several times. It is not an accurate method for all species since in animals which have ovulation induced by copulation, the "heat phase" of the oestrus cycle may be evident for several days or weeks until copulation has taken place. Use of vulvar swelling as a breeding time index presents similar difficulties. The exact stage of vulvar swelling at which copulation takes place is not known for all game and fur animals. A more reliable indicator is a smear showing sperm. This procedure is complicated by the fact that some animals are known to copulate several times during one oestrus cycle. For example, Dr. Robert K. Enders has informed me of performing a laparotomy on a pregnant raccoon which had sperm in the vagina and was bearing 25 mm. embryos. I have observed captive foxes copulate daily over a period of four days.

Since pregnant females of most game and fur animals can frequently be collected, it would seem possible to determine the date of breeding fairly accurately by size of embryo, provided that the relationship between size and age of embryo is known. To determine if this

procedure is feasible with the raccoon (*Procyon lotor*) the following experiment was conducted.

On March 25, 1952 an adult female raccoon of average size was live-trapped on the Patuxent Research Refuge, Laurel, Maryland. She was known from previous records to be four years old and to have had her first litter in 1951. She was placed in a cage with an adult male and observations were made daily. On March 29, sperm in the vaginal smear proved that the animals had mated the previous night and the male was removed.

On April 18 (21st day of gestation) the animal was anesthetized with ether and a laparotomy was performed by Dr. Enders. Three embryos 24 mm. long (crown-rump, or greatest measurement across curve of embryo) were found. Two were in the left horn and one in the right, and all apparently were developing normally. The animal continued in captivity and on May 2 (35th day of gestation) a second operation was performed. At this time the fetuses were 45 mm. long. When a third laparotomy was performed on May 13 (46th day of gestation), the fetuses were 65 mm. long. On this occasion quite a large incision was necessary to explore and measure them, but apparently no ill effects were experienced by either adult or fetuses. Incisions healed readily and the fetuses appeared normal as judged by many others observed during similar laparotomies.

The gestation period of 63 days was completed on May 31 when the three young were born. They were normal in every observed respect. Measurement of these and other young at birth and of fetuses near parturition has established the size of the fetus at term at about 95 mm. (crown-rump).

The three laparotomy measurements plus the birth size of about 95 mm. are plotted in Fig. 1 to give an indication of

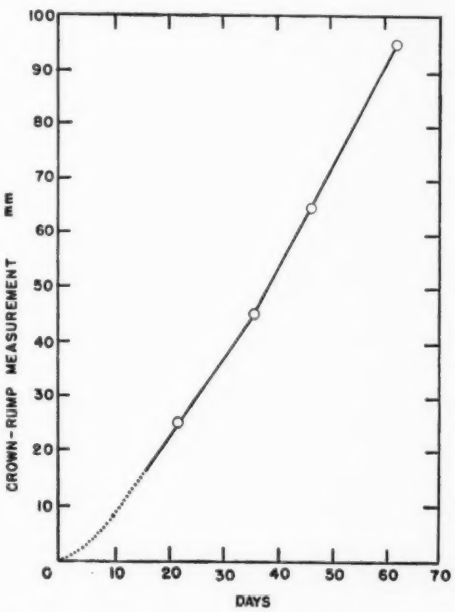

FIG. 1. Size of embryos at 21st, 35th, and 46th day of gestation and at birth.

the rate of development of the fetuses of this raccoon. The lower portion of the graph is dotted to indicate that data for this period are not available. The figures given are for one average-sized litter only, and no doubt some variation occurs. Use of this graph, however, should give reasonable accuracy in determining the age of a given-sized fetal specimen, or conversely, fetal size at any given period of gestation.

Accepted for publication October 30, 1952.

TOLERANCE OF INCUBATING PHEASANT EGGS TO EXPOSURE

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Michigan's ring-necked pheasant (*Phasianus colchicus*) population, in common with pheasant populations across the rest of the continent, underwent a decline in the mid-1940's. The decline was characterized by a lessened production of young, as evidenced by lower fall age ratios, and by a decreased proportion of hens observed with broods in summer. The average number of chicks in each brood, however, did not change significantly in Michigan during the years of decline and subsequent recovery. This suggests that the factors operating to limit reproduction prevented entire clutches from being laid or from hatching, or destroyed entire broods, rather than operating by destruction of eggs or chicks one by one.

During the early years of the decline there appeared to be some correlation of lowered production of young with lowered mean temperatures and excessive precipitation in spring months. Allen (1946) reported this in Michigan, and Ginn (1948) found an apparent inverse correlation between amount of spring precipitation and fall kill. Kimball (1948) stated that 11 of 12 pheasant workers listed weather as a likely cause of the pheasant depression. In later years of the pheasant "low" and during subsequent recovery, this apparent correlation has not always followed; it is now obvious that there is no simple relationship between spring weather and fall populations.

Nevertheless, since climatological factors are influential in determining range of a species, and since there still was the suspicion that annual climatological conditions affect yearly population fluctuations of the shorter-lived species, experimentation to determine climatic toleration of pheasant eggs seemed worthwhile. A series of experiments was devised in which eggs in various stages of incubation were exposed to lowered temperatures or simulated rainfall for varying periods of time. Work was done at the Michigan Department of Conservations's game farm at Mason, Michigan, as part of Pittman-Robertson Project W-38-R, "Survey of the Ring-necked Pheasant in Michigan."

Examination of the literature reveals references to limited experiments with (1) exposure of unincubated pheasant eggs to lowered temperatures, (2) exposure of incubating pheasant eggs to higher than normal temperatures, (3) exposure of incubating and unincubated chicken eggs to lowered temperatures. But no references to the effects of lowered temperature on incubating pheasant eggs could be found.

English (1941) found that unincubated pheasant eggs could be exposed to temperatures as low as 10° F. for a total of $5\frac{1}{2}$ hours in three $1\frac{1}{2}$- or 2-hour periods on alternate days without appreciable loss of viability. Romanoff *et al* (1938) reported on the effects of incubation temperatures varying between 95°

F. and 105° F., but did not discuss the effects of exposure to low temperatures.

Moran (1925) found that hatchability of unincubated chicken eggs exposed to 33.3° F. was 70-100 per cent after 113 hours of exposure, 30 per cent after 161 hours, and 16 per cent after 237 hours. Exposures greater than 237 hours reduced hatchability to zero. He also determined that unincubated chicken eggs could be stored up to 15 days at 46-60° F. with 90-100 per cent hatchability. After 17-20 days hatchability dropped rapidly.

There are several references to effects of lowered temperatures on incubating eggs. Kaestner (in Edwards, 1902) found that cooling chicken eggs to room temperature (21° C.) during incubation would arrest development and limit the life of the embryo. He found that as incubation progressed the length of survival of the embryo became progressively shorter. Dareste (in Edwards, 1902) cooled incubating chicken eggs to 20° C., 15° C., 8-10° C., and 1-2° C. for long periods of time without killing the embryo. Stages of incubation are not specifically mentioned. Lamson and Kirkpatrick (1918) found that hens' eggs will stand 4-5 hours' exposure to 50° F., after the first 24 hours of incubation. Fifteen hours' exposure on the 10th-12th day did no damage. After the 17th day, 6 hours' exposure killed the embryo.

METHODS

The first experiment, conducted in June, 1949, was designed to determine approximate thresholds of tolerance to low temperature. Following this, a series of experiments was conducted to determine these thresholds more closely and to study effect of rainfall. Eggs were obtained from the game farm's ring-necked pheasant breeding stock. Eggs were gathered from laying fields four times daily and stored in a cool basement room. They were produced in sufficient quantity that none used in this first experiment was more than one week old, and the majority were less than four days old when set. In subsequent experiments, however, eggs were stored longer, and viability was not as high.

All eggs were incubated in 21,000-egg capacity Buckeye circulating air incubators. Incubation temperature was 99.7° F. and varied less than one Fahrenheit degree. Humidity was automatically controlled at 86 per cent (measured by wet-bulb thermometer) and did not vary more than one per cent. Trays were automatically turned through 90° every 3 hours.

After incubation had begun, eggs were removed in lots of 20 for exposure to various conditions. To provide the low temperatures, two ice-cooled refrigerators, an automatic electric refrigerator, and an electric, manually regulated deep freeze unit were used. A combination of salted ice and a small electric fan was used to control temperatures in the ice-boxes. Reasonably accurate temperatures were maintained, although fluctuation of three Fahrenheit degrees occurred in some cases.

No attempt was made to regulate humidity. With the exception of eggs exposed to room temperatures, humidity in the refrigerators was as high as, or higher than, humidity in the incubator. Romanoff *et al* (1938) reported that incubation at 80 per cent humidity produced only 5 per cent better hatchability than incubation at 50 per cent humidity, so it is unlikely that the temporarily

lower humidity of eggs exposed to room temperature had an important influence.

On the 21st or 22nd day of incubation, eggs were transferred to 7,200-egg capacity Buckeye circulating air hatchers which operate at 97° F. and 87 per cent humidity. They remained there until hatching was completed. Following hatching, chicks were wing-banded for identification and placed in brooder houses.

Each set was identified by a coded letter-number combination written in pencil on each egg. In the first experiment a dab of oil paint was used as an identifying mark. Under the suspicion that oil paint might injure the embryos, this was not done in subsequent experiments. No evidence was found that the oil paint injured the embryos in this first experiment.

EXPLORATORY EXPERIMENT

In the preliminary experiment, only the effect of temperature was considered. A total of 2,500 eggs was used, of which 1,800 were exposed to cooling and the balance used as controls and spares in case of breakage. Eggs in lots of 20 were exposed to temperatures of 65° F., 55° F., and 45° F. for periods of 1, 2, 4, 8, 16, and 24 hours.

All exposure tests were made on eggs incubated to the 2nd, 4th, 10th, 16th, and 22nd days, making a total of 90 different combinations of stage of incubation, temperature, and length of exposure.

No attempt was made to determine fertility before exposure. For this reason a hatch of 70 per cent or above was considered to indicate no mortality attributable to cooling. This was based on expected hatchability in routine production at the game farm.

Survival of exposed eggs is shown in Table 1, which is a composite of all experimental phases involving lowered temperature alone. The boxed areas indicate exposures in which chilling definitely resulted in mortality.

Survival percentages for the above experiment are based on eggs pipped or hatched by the 26th day of incubation. There is a possibility that experimental eggs might contain chicks weakened by exposure, which could pip the egg but not break out. However, of 60 control eggs pipped but still not hatched by the end of the 26th day, 35 per cent (21) managed to break out; of 221 experimental eggs pipped on the same day, 34 per cent (76) managed to hatch. Thus exposure to cold apparently does not unduly inhibit final hatching of pipped eggs.

As would be expected, embryos which survived chilling evinced some delay in hatching. The delay was generally less than the length of the exposure.

Survival after hatching was very good. Records were kept on 1000 wing-banded chicks until they were six weeks old. Chicks which had undergone severe exposures in the egg appeared to have a higher post-natal survival than those hatching from lots subjected to short exposures.

In order to determine when embryos killed by exposure died, unhatched eggs of the 16th-day sequence were autopsied. The weights of these 92 embryos fell into three distinct classes. Seventy-three (79 per cent) were in the 5-9 gram class, indicating death at about the 16th day of incubation when the eggs were chilled. Romanoff *et al* (1938) re-

ported that pheasant eggs (consistent with eggs of all birds, presumably) suffer an expected high mortality just prior to hatching. Thus the death of 14 embryos (4.3 per cent of the 322 fertile eggs chilled at 16 days) just prior to hatching may be an expected mortality and not a result of the chilling. Five embryos in the 11-14 gram class may represent a delayed mortality. But it is apparent that the bulk of the mortality occurs at about the time of exposure.

It was evident that this exploratory experiment was too conservative. Only a few sets of eggs showed any mortality. This experiment indicated, however, approximately where mortality began, and so immediately we set up additional experiments.

Pheasant flocks were beginning to lessen egg production and breeders were being disposed of, so it was necessary to store eggs longer before a setting was accumulated. Thus a smaller percentage of the eggs was viable, and we could no longer depend upon a 70 per cent hatch to evaluate survival. Moreover, facilities were no longer available at the

TABLE 1.—PER CENT SURVIVAL OF INCUBATING PHEASANT EGGS EXPOSED TO LOWERED TEMPERATURES

Temperature of exposure	Hours of exposure	Day of Incubation							
		2	4	6	8	10	14	16	22
68–72° F.	30					*91*	*100*	*100*	
	48					*86*	*94*	*23*	
	60					*90*	*50*	*7*	
65° F.	8	80	90			75		80	85
	16	89	80			80		95	85
	24	90	70			72		72	60
55° F.	8	80	80			75		90	65
	16	70	85			100		80	45
	24	90	77			70		13	5
45° F.	8	73	75			100		85	80
	10								*21*
	12								*11*
	16	77	60			85		0	0
	24		55			8		0	0
	30	*74*	*67*	*0*	*0*				
	36	*71*	*67*	*0*	*0*				
	48	*71*	*7*	*0*	*0*				
32° F.	1								*90*
	2								*100*
	3								*89*
	4								*80*
	5								*70*
	6								*25*
	7								*20*

game farm for raising chicks. So we decided to evaluate survival by counting hatched chicks and autopsying remaining unhatched eggs. Thus, survival of embryos in these succeeding experiments is measured as per cent of fertile eggs. Obviously, then, these percentages (shown in italics in Table 1) will often be higher than those in the first experiment where number of pipped and hatched eggs was used as the survival criterion.

REFINEMENT OF 45° F. THRESHOLDS OF TOLERANCE

In order to determine the length of exposure necessary to kill embryos in the early days of incubation, and to determine more exactly the length of exposure necessary to kill eggs just before hatching, another series was exposed to 45° F. temperatures. Major results of these exposures are shown in Table 1.

It seems obvious from the first and second experiments that eggs in early stages of incubation are much more tolerant to lowered temperatures than eggs in advanced stages of incubation.

In the first experiment it had been established that 22nd-day eggs did not suffer mortality when exposed to 45° F. for 8 hours. In this second experiment similar eggs did suffer heavy mortality after 10 hours of exposure. Thus the threshold for 22nd-day eggs exposed to 45° F. temperatures lies somewhere between 8 and 10 hours.

THRESHOLD OF TOLERANCE TO 32° F. AND ROOM TEMPERATURES

Two new temperatures not used in the first experiment were tried. A series of 15 sets of eggs was exposed to room temperatures, varying between 68° F. and 72° F. The important results of these exposures are included in Table 1. Due to a particularly poor group of eggs, data for early stages of incubation were inconclusive. Even on the 14th and 16th day, however, exposures of 60 and 48 hours respectively were necessary to induce mortality, so it may be assumed that greater exposures would be required to induce mortality in early stages of incubation.

For the 32° F. exposure, only enough eggs were still available to test two stages of incubation, so eggs incubated to the 9th and 16th days were used. Due to mechanical trouble with a cooler the 9th-day eggs were exposed to a temperature of 40° F. rather than 32° F. Since no comparable data are available, this 40° F. exposure is of little significance here and is not included. Results of the exposure of 16-day eggs to 32° F. are included in Table 1. Mortality apparently began to occur between the 5th and 6th hours of exposure.

In general, the first 3 experiments have shown that survival is reduced as incubation progresses and as the temperature is reduced.

Figures 1 and 2 show the approximate thresholds of survival. Exposures resulting in little or no reduction of survival are indicated by a plus (+) sign. Exposures resulting in greatly lowered survival are indicated by a minus (−) sign. It should be noted that no exposures were made between the limits given, so that actual thresholds may lie at any point within these limits.

The distribution of limits for the 45° F. series (Figure 1) and the 16th-day series (Figure 2) suggests that the function relating variables of temper-

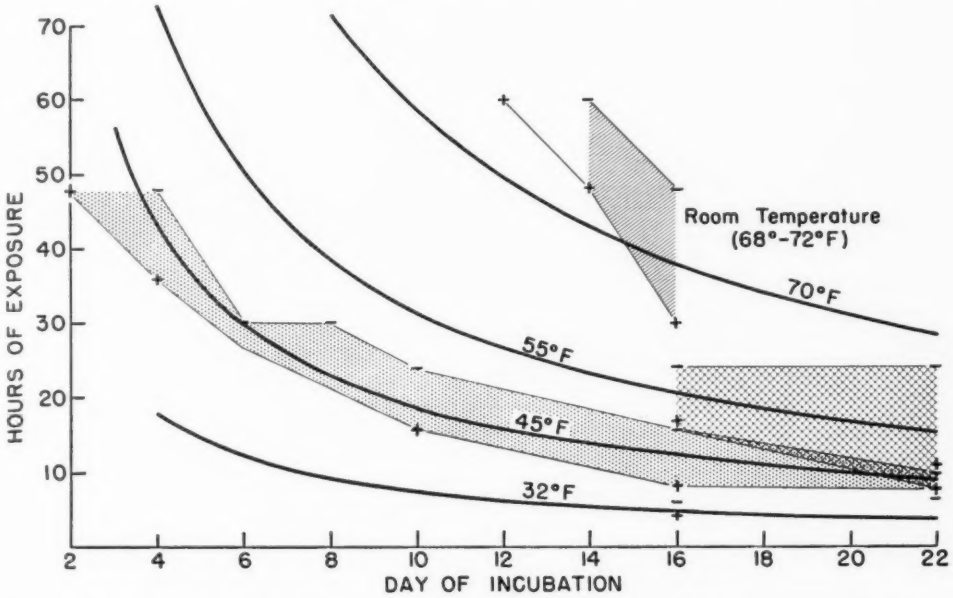

FIG. 1. Survival limits of incubating pheasant eggs exposed to lowered temperatures. Plus (+) signs indicate normal survival. Minus (−) signs indicate low survival or no survival. The heavy lines represent calculated points of 50 per cent survival at the given temperature.

ature, exposure, and stage of incubation is non-linear.

The observed limits are satisfied, however, by an exponential relationship which relates the conditions of temperature, length of exposure, and stage of incubation necessary to produce 50 per cent mortality. This equation is conveniently expressed as follows:

$$1.24 \log T = .48 \log E + .44 \log I + 1$$

where T = temperature in degrees F.
E = length of exposure in hours
I = stage of incubation in days
(logarithms to the base 10 are used)

Points plotted from this equation are connected by the solid lines shown in the figures. We do not anticipate that this equation will prove very accurate, nor do we maintain that the actual relationship is exponential. However, it should provide reasonable estimates and may be useful as a guide for those wishing to do similar work with other species where a limited number of eggs is available.

The following points should be emphasized in connection with the equation:

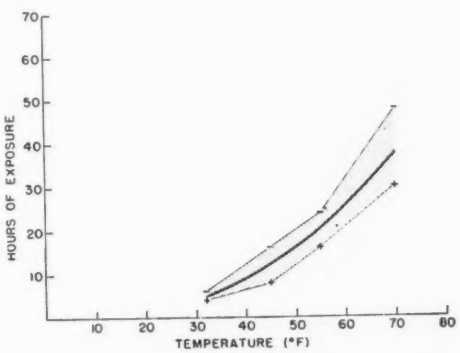

FIG. 2. Survival limits of incubating pheasant eggs exposed to lowered temperatures on the 16th day of incubation. Plus (+) signs indicate normal survival. Minus (−) signs indicate low survival. The heavy line represents calculated points of 50 per cent survival.

(1) The equation was derived from the estimated points of 50 per cent mortality. Thus values obtained through its use should lie between "normal" survival and very low survival.

(2) Extrapolation beyond the limits of observed data is generally a dubious procedure. We have no evidence as to the validity of the extended curves shown in Figure 1.

(3) From Figure 1 it may be seen that the calculated room temperature curve (68-72° F.) does not fit the observed limits in all cases. This may result from the variability of the room temperatures during the experiments or may indicate that the relationship given does not apply at higher temperatures. Edwards (1902) found that embryonic development begins in chicken eggs at 68-70° F. It seems possible that the proposed relationship may not apply when exposure temperatures are such that embryonic development may continue.

EFFECT OF SIMULATED RAIN

The possibility that eggs might be exposed to rainfall or flooding led to this experiment. A series of 16th-day eggs was subjected to a steady shower of water (60° F.) and a second series was soaked in water (68°-72° F.). Table 2 shows the pertinent data.

The survival thresholds for simulated rain appear to be considerably lower than would be expected as a result of the same temperature operating alone. Immersion in water markedly reduced survival. However, Table 2 shows that some embryos survived 48 hours of soaking.

Approximately half of the eggs used in the "soaking" experiment floated and the balance sank to the bottom of the container. Lots taken for return to the incubator were composed of about half "floaters" and half "sinkers." Unfortunately records were not kept of the hatching success of the two categories, thus it is possible that some of the "sinkers" were asphixiated, but probably not in less than 4 hours, since survival appears normal for this exposure length.

TABLE 2.—SURVIVAL OF EGGS EXPOSED TO SIMULATED RAIN AND FLOODING
(16th day of incubation only)

Hours of Exposure	*Per Cent Survival*	
	"Rain"	"Flooding"
2	92	
4	85	78
6	63	
8	100	53
10	63	
12	7	25
14	0	
24		21
36		8
48		14

ALTERNATE COOLING AND INCUBATION

In order to explore the possibility that the shock of repeated coolings would affect survival, a series of 16th-day eggs was alternately cooled and incubated. Chilling periods were 2 hours and incubation periods 4 hours. Eggs were exposed in the electric refrigerator which was maintained at 45° F. Each lot was quickly brought down to this temperature by a short exposure in the deep-freeze.

The lots were exposed as follows:

	Hours of Cooling and Incubation	*Total Elapsed Chilling*	*Per Cent Survival*
Lot 1	2 - 4 - 2 and returned to incubator	4 hours	100
Lot 2	2 - 4 - 2 - 4 - 2 - 4 - 2 and returned to incubator	8 hours	91
Lot 3	2 - 4 - 2 - 4 - 2 - 4 - 2 - 4 - 2 - 4 - 2 - 4 - 2 and returned to incubator	14 hours	92

Allowing for the time it took eggs to cool at the start of each chilling, actual elapsed time of chilling was somewhat less than indicated. Survival was high in all cases, suggesting that such alternate chilling and incubation may not be appreciably more lethal than continuous cooling. Kendeigh and Baldwin (1932) have suggested that alternate cooling and incubation may even be stimulating.

Effect of Exposure on Newly-Hatched Chicks

Seventeen newly-hatched chicks were placed in the refrigerator at 45° F. Survival was as follows:

Number exposed	*Exposure*	*Survival*
4	15 minutes	4
4	1 hour	3
9	3 hours	0

Survival figures are taken 12 hours after chicks had been returned to a hatcher following exposure. Chicks were active after 15 minutes' exposure, but had become lethargic after one hour (several were unconscious). None survived after three hours' exposure.

Summary

Incubating pheasant eggs were subjected to low temperatures and simulated rain for various lengths of time. From the tolerance data thus obtained, an equation has been set up to approximate the relationship between temperature, stage of incubation, and length of exposure as affecting survival.

Conclusions

1. As exposure temperature is lowered, length of time pheasant embryos can safely tolerate exposure decreases.

2. Embryos are progressively more vulnerable to exposure as incubation progresses.

3. Alternate cooling and incubating do not cause higher mortality than a similar elapsed time of continuous cooling.

4. Exposure to simulated rainfall or flooding reduces the survival threshold below that of simple cooling to approximately the same temperatures.

5. Death from chilling evidently occurs during the exposure. "After-effects" are of minor importance.

6. Newly-hatched chicks exposed to lowered temperatures are much more vulnerable than eggs in any stage of incubation.

The tolerance shown by pheasant eggs in these experiments was considerably greater than popularly supposed. For much of the incubation period, tolerance is great enough that widespread mortality from unseasonal cold spells would not likely occur in the wild.

There are two possibilities for widespread mortality of chicks or eggs in the wild, however, that warrant further consideration and study.

1. Changes of habits of hens during cold, wet weather could affect survival of eggs in the wild. At "normal" spring temperatures, hens apparently do not remain off the nest long enough to allow lethal chilling. A change in habits of hens during cold weather at late stages of incubation, when eggs are more vulnerable, however, could allow lethal exposure.

2. Chicks appeared markedly less tolerant to cold than eggs in any stage of incubation. While the experiment with chicks was limited, it suggested that chicks are highly dependent upon the brooding hen for warmth. Conceivably, severe cold, especially in conjunction with precipitation, could cause widespread mortality, if it occurred at a time when a large proportion of the chick population was vulnerable.

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Accepted for publication November 8, 1952.

AGRICULTURAL DEPREDATION BY THE BLACK BEAR IN VIRGINIA

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All evidence indicates that the black bear, *Euarctos americanus americanus* (Pallas), is gradually increasing in numbers and in the extent of its range in Virginia. This species is classed as game and is protected by law except when it commits acts of depredation. Its increase in Virginia in recent years has resulted in increasing numbers of claims that bears are committing acts of depredation on agricultural products, particularly livestock, corn, apiaries, and orchards. This investigation was made to obtain as much information as possible on the types and extent of losses caused by black bears.

The first step was to collect all available information concerning the distribution and relative abundance of the bears in Virginia. Little difficulty was experienced in determining the extent of the occupied bear habitat in the various sections of the state, but determining the bear population presented quite a problem. No accurate method of censusing bears has been developed. For this reason it was necessary to utilize the best possible estimates of the population. These were gathered from persons familiar with the bears in each section of the state. When possible, more than one estimate was obtained for each locality.

The distribution and relative abundance of the bears is indicated in Figure 1. It will be noted that there are two distinct areas used by bears in Virginia. They are present in the Dismal Swamp section in the extreme southeastern tip of Virginia, and in the mountainous regions of the western part of the state. Very rarely a bear is reported in the Piedmont; however, no records were secured of depredation outside the occupied habitat shown in Figure 1.

Observations and reports indicate that bears often travel considerable distances in search of food. This makes it difficult to obtain an accurate estimate of the number of individual animals present in any area. However, game wardens, bear hunters, and other persons familiar with the bears usually have a fairly good idea of the number of animals present as indicated by various "signs." Information obtained from such people, together with rather reliable kill figures, does permit an intelligent estimate of the number of bears present in an area. Estimates of the population in various sections of Vir-

[1] Release No. 53-1 of the Virginia Cooperative Wildlife Research Unit; The Virginia Polytechnic Institute, the Virginia Commission of Game and Inland Fisheries, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service, cooperating. The data herein presented were collected when the writer was a graduate fellow of the V. P. I. and this paper is an extract from a master's thesis. Sincere appreciation for assistance in collecting the data is extended to the State Game Wardens and District Game Technicians, especially Game Technician Charles H. Peery and Wardens W. S. Rountree, L. E. Styne, and C. H. Corbett.

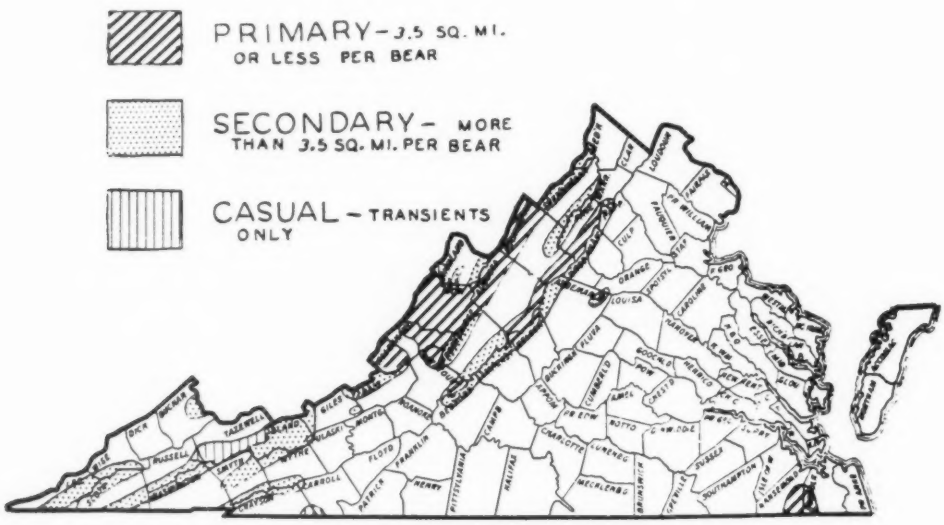


FIG. 1. Distribution and relative abundance of the black bear in Virginia, 1950.

ginia are presented on a county basis in Table 1. The area of occupied habitat was measured by planimeter on the mapped distribution in each county and the number of square miles per bear was calculated by dividing the estimated population into the number of square miles of occupied habitat.

Bears may be found in 35 of the 100 Virginia counties at some season. There is a permanent population in 32 counties, and three others (Carroll, Dickenson, and Tazewell) usually have a few transient animals each summer and fall.

Slightly more than half of the seven hundred and forty-nine square miles of the Dismal Swamp is in North Carolina. The estimated bear population of Virginia's portion of the Swamp is three hundred animals. There is very little dry land inside the borders of the Swamp and, where water is not actually standing on the surface, the ground is thoroughly soaked and usually composed of soft mud and debris. Except when traveling along fire trails and old logging roads, any person attempting to penetrate the interior is forced to wade or paddle. For this reason, the bears are largely unmolested unless they come out beyond the borders of the Swamp. Most of the bears killed in the Swamp are killed when they are driven out of the interior by deer hounds and are shot by deer hunters on stands along the fire trails and old roads. Occasionally farmers shoot individual bears in corn fields while they are destroying crops.

Since the bears there are relatively undisturbed, the population in the Swamp is the densest in the state. It is estimated that there is one bear for every 1.1 square miles in the Dismal Swamp of Virginia.

The Blue Ridge and Allegheny Mountains run northeast to southwest along the western third of the state. Thirty of the forty-odd counties in which these mountains lie have permanent bear

TABLE 1.—ESTIMATED 1950 BEAR POPULATION OF VIRGINIA, BY COUNTY, WITH THE NUMBER OF SQUARE MILES OF OCCUPIED HABITAT PER BEAR IN EACH COUNTY

County	Estimated No. of Bear	Sq. Miles per Bear	County	Estimated No. of Bear	Sq. Miles per Bear
Albemarle	12	12.0	Madison	6	11.3
Alleghany	150	1.8	Nansemond *	125	1.1
Amherst	50	3.2	Nelson	75	2.1
Augusta	200	2.4	Norfolk *	175	1.1
Bath	250	2.2	Page	100	2.0
Bedford	6	23.2	Rappahannock	1	19.7
Bland	25	14.3	Rockbridge	50	4.4
Botetourt	60	2.4	Rockingham	175	3.0
Buchanan	1	97.6	Russell	2	67.7
Carroll	0	—	Scott	20	13.9
Craig	5	13.4	Shenandoah	50	4.4
Dickenson	0	—	Smyth	10	16.1
Frederick	3	20.0	Tazewell	0	—
Giles	6	14.5	Warren	6	4.0
Grayson	12	5.7	Washington	25	6.1
Greene	12	4.1	Wise	3	22.8
Highland	20	7.7	Wythe	10	11.8
Lee	2	115.0			

Total estimated number of bear in Virginia in 1950	1,547
Average number of sq. miles of habitat per bear	15.2

* Dismal Swamp

populations and at least three additional counties have transient bears moving through at various times, principally during the summers. A majority of Virginia bears is found in the western Virginia mountains and it is here that most of the bear depredation complaints are voiced.

Definite evidence may be cited in regard to an increase in the number of bears in western Virginia in the past fifteen years. According to game wardens, there were no bears in Scott, Wise, Washington, or Russell Counties fifteen years ago. Ten years ago there were none in Greene or Grayson Counties, and bears have come into Frederick, Warren, Rappahannock, Madison, Bland, Wythe, Smyth, and Lee Counties in the past five years. The estimated number of bears in these fourteen counties in 1950 is 128.

Practically all of the bears found in the mountainous counties are in National Forests where they are, for the most part, out of the way of humans. Black bears under ordinary circumstances are extremely shy (Alexander, 1890; Wright, 1910; Seton, 1929) and even in the National Forests they normally stay well back in the rougher sections of the mountains. Occasionally, however, a bear will come down to the nearest farms on a foray, and damage claims usually result.

TYPES OF DEPREDATION

Bear damage has occurred to crops, livestock, fruit trees, and apiaries in Virginia. Corn is the only crop molested

to any extent; no other crop has been reported to have suffered from raids by bears. Among livestock, sheep are the most often killed, with hogs, goats, calves, and cattle following in order. Fruit trees and apiaries are occasionally damaged. Often, too, they destroy Forest Service trail markers and mar telephone poles, but this type of damage is seldom more than a nuisance.

The only complaints of significant amounts of corn damaged by bears come from areas directly adjacent to the Dismal Swamp. In this region there are a number of farms which extend short distances into the Swamp itself. Others are located against the edge of the Swamp and run along it for some distance. Those farmers who have corn fields impinging upon the Swamp margin are the ones who suffer damage from bears, as it is extremely rare for a bear to travel far from the Swamp to get corn.

Rarely, a corn field in the mountainous areas of the state may be visited by bears. Game commission officials generally hear such reports mentioned casually more as a curiosity than as a complaint.

Bears eat corn from the time it reaches the milk stage until it has been harvested, but they much prefer it in the roasting ear stage. In the vicinity of the Dismal Swamp, the roasting ear stage in corn growth is usually reached about the middle of August and most of the corn damage occurs at that time of the year.

So far as is known, bears visit the corn fields only at night. This fact is utilized locally in the control of pillaging bears by shooting them at night from scaffolds erected in corn fields where damage is being done.

Black bears, generally speaking, are animals of fixed habits. In moving from one place to another, a bear will generally try to use a path he has previously travelled (Alexander, 1890; Wright, 1910; Seton, 1929). This habit exists even in quite open areas, so that bears will use the same trail repeatedly when entering and leaving a corn field if they are not disturbed.

Once a bear has entered a field, he selects a spot to his liking and begins gathering all the nearby corn stalks to him. In doing this he may completely demolish all the stalks within a five-foot radius. When he has gathered what he wants, he usually eats only a few of the ears at hand, then moves to another spot to continue his feeding. Bears probably eat less than a third of the corn which they destroy. As many as ten of these small areas of destruction, often being within twenty feet of one another, have been observed in one corn field. These pillaged areas were not the only damage evident in the field. As the bear had moved from place to place in the field, he had left a broad trail of broken and down stalks.

Generally, when a bear has eaten as much corn as he wants during a single night, he will leave the field without doing further harm. Several fields have been observed, however, where bears have made an effort to carry off a supply of corn with them. In these places, stalks were strewn along the ground for a distance of one hundred yards or more from the field into the adjoining swampland. Most of the ears on these stalks had not been touched, but were abandoned, uneaten, at the field margins.

Practically all stock killing by bears in Virginia occurs in the mountainous sections of the state. Only one farm located in the Dismal Swamp region reported a loss of stock and this was a loss of hogs only. A number of farmers in this area allow their hogs to forage in the Swamp for mast in the fall. Some of these free ranging hogs are lost every year, but their disappearance cannot definitely be blamed upon bears and no effort on the part of the owners is made to do so. The one man who reported the kill of hogs based his claim upon direct observations.

Usually livestock losses begin between the middle of March and the first of April. The peak of damage is reached in the early spring after the bears have become active following the period of winter quiescence and when natural foods are scarcest. At this time of year they are inclined to use whatever edible items they can find. Normally, livestock losses due to bears cease about the first of November. It is of interest to note that the period from March to November, when most bear damage occurs, is also the time of year when most livestock is on mountain pastures which are often well within bear habitat.

In the Dismal Swamp area, all of the hogs lost by the one man who reported losses were taken during daylight hours. On several occasions, members of this man's family have run from the house to drive bears away from hogs which were being attacked within two hundred yards of the farm residence. As far as could be learned, almost all stock losses in the mountains have occurred at night. If any attacks have been made upon stock during daylight hours in this region, they have not been reported.

Bears are inclined to be carrion eaters (Wright, 1910; Seton, 1929); therefore establishing the fact that a bear killed the livestock upon which he fed is very difficult if the dead animal is not examined very shortly after its death.

Investigation has revealed that no two bears are likely to go about killing stock in exactly the same manner. There is, however, a general pattern common to most kills. The death of an animal attacked is usually effected by a bite through the nape of the neck or through the spine just behind the shoulders. Frequently the bear will then remove the carcass to a more secluded spot to eat, if the kill is made in an open place. Occasionally a kill may be moved for no apparent reason. In moving the carcass, the killer may either drag it over the ground or pick it up and carry it. If the bear carries his kill, he may do so either by holding it in his teeth and throwing the body over his shoulder, or by holding it with his teeth and forearms and walking erect on his hind legs. This erect method of transporting the prey has been observed by two game wardens and others have mentioned that they have followed tracks which distinctly indicated that the bear was walking erect.

If the animal killed is a female, the udder is ordinarily eaten first. The body is then split open ventrally and the heart and liver taken out. When these organs have been consumed, the bear will usually begin skinning the animal to get at the more firmly fleshed parts. Generally, the skinning is done from the hind quarters toward the head, but frequently it may start at the shoulders and extend toward the tail. A bear seldom swallows much wool or hair in

eating, but rolls the skin back from the carcass almost as neatly as a man might do. In spite of this, enough wool or hair is ingested to identify definitely the stock killer if he should be killed within a reasonable time after eating his victim. Evidence of the killer's defecation may ordinarily be found within a radius of about one hundred feet from the carcass upon which he has been feeding.

After having eaten as much as he wants, a bear will usually make a bed and lie down somewhere near his kill, usually in a place from which he can see it. This bed near the kill apparently is not for the purpose of guarding his food, however, since bears are not known to have interfered with any other animal attempting to make a meal from the carcass (Seton, 1929). This bed is frequently within one hundred yards of the kill if cover is available, but may be quite a distance away.

Of the above-mentioned characteristics of stock-killing by bears, only the bite through the neck definitely indicates a bear kill. All other evidence may be found in cases of carrion feeding, except the bed near the carcass. A bed in the immediate vicinity of carrion is rare.

So far as could be determined, all of the known stock-killing bears in Virginia have been old males, with the possible exception of an old female bear taken in southwestern Virginia. Virginia law permits the use of dogs to hunt stock-killing bears at any season of the year, provided the hunt, under the supervision of the state game warden, is started within twenty-four hours after the act of depredation. Not infrequently female bears are killed on such hunts. On all occasions when females were disposed of as stock killers, except the one mentioned above, losses of domestic stock continued. No detailed investigations have been made to determine whether or not only old males kill stock, but what evidence there is strongly indicates that such is the case (McCracken and Van Cleve, 1947, p. 170).

Actually, only a very few bears become stock-killers. Once a bear has acquired the habit of killing stock, he seldom, if ever, loses it (Seton, 1929; Cahalane, 1947), though he may not kill during periods when other foods are abundant.

If a bear is undisturbed and eats his fill from the carcass, he will usually wait until the second night afterward before returning to it for another meal. Generally, if he is disturbed on the night of the kill, he will return the following night or not at all. However, the chances of his coming back after having been disturbed are considerably less than if he had been left alone. It is unusual for a bear to return to a kill later than the third night after it was made; in fact, it is a rare occasion when one returns as late as the third night afterward.

THE VALUE OF AGRICULTURAL LOSSES DUE TO BEARS

In order to ascertain the approximate monetary value of agricultural losses due to bears, data were collected on: (1) the value of the corn and stock loss for each year from 1941 through 1950; (2) the total losses for the ten-year period; and (3) the relative importance of these losses as compared with the total value of the stock or

crops sold in the counties where damage had occurred.

As far as could be discovered, no written records, either public or private, concerning the quantity or value of the corn loss to bears, are kept by persons in the vicinity of the Dismal Swamp. The game wardens of Norfolk and Nansemond Counties were asked for their estimates of the value of the corn annually destroyed by black bears. A dozen different farms, where damage is usually quite heavy, were then visited. Each farmer was asked for estimates of his personal losses as well as his estimate of the total annual value of corn loss in the area about the Swamp. The data supplied by the wardens and the various farmers were used in arriving at an estimate of the monetary value of corn destroyed annually by bears near the Dismal Swamp.

The general consensus was that each farmer whose fields were raided by bears lost an average of from fifty to seventy-five dollars per farm per year. Approximately thirty farms suffer damage by bears; thus the estimated total value of corn damage is $1500 to $2000 per year in the area immediately about the Dismal Swamp. This was also the estimate made by each of the game wardens. Since the estimates made by the wardens and by the farmers agreed so closely, it is thought that these figures are a reasonable approximation of the losses sustained by farmers in that region.

It should be remembered that this estimate is for the average annual loss and that the actual amount of damage in any one year may be greater or smaller, depending largely on two things: first, the amount of natural food available to bears in that particular year; and, second, the amount of corn planted in the fields adjacent to the Swamp in that year. The actual value of the corn loss usually varies quite a bit from year to year.

All corn damage by bears occurred in Norfolk and Nansemond Counties. The value of the corn sold in these two counties in 1950 amounted to $1,525,150 (Department of Commerce, 1951). Thus, the value of the corn lost to bears in the Dismal Swamp area, assuming that approximately $2000 worth of corn was destroyed there in 1950, amounts to only 0.13 per cent of the total value of the corn produced in this area during this year. It must be remembered, however, that the $2000 damage was sustained by only some thirty farmers and the loss per farmer is of greater significance to the individual than if it were spread over all corn producers in these two counties.

In eleven western Virginia counties stock losses to bears have been sufficiently frequent to cause the county governing bodies to establish a system of reimbursement for these losses from public funds. In these counties public records of all such payments have been kept. The game wardens were able to supply all necessary information regarding stock killed by bears in those counties which have no reimbursement system. It was possible, therefore, to obtain reasonably complete records of the claim value of livestock destroyed by bears in Virginia. It will be noted in Table 2 that livestock (including sheep, hogs, goats, and cattle) having a total claimed value of $22,324.44 were killed by bears during the ten year period 1941-1950. In most instances, the value

TABLE 2.—YEARLY VALUE OF OWNER CLAIMS FOR STOCK KILLED BY BLACK BEARS IN VIRGINIA DURING THE TEN YEAR PERIOD 1941–1950

Year	Amount of Claims	Year	Amount of Claims
1941	$ 211.33	1946	$2,162.26
1942	270.33	1947	2,190.76
1943	1,418.76	1948	3,195.76
1944	1,334.26	1949	3,430.76
1945	2,213.46	1950	5,896.76
Total amount of claims			$22,324.44
Average per year			2,232.44

of the individual animals killed was based on the tax assessment value of the animals as declared by the owner for purposes of property taxation. It is, therefore, unlikely, under these circumstances, that the value of the stock killed was exaggerated. It is interesting to note from Table 2 that the claims for stock lost to bears have increased considerably during the ten year period. This increase may be due to an actual increase in livestock prices, an increase in the number of bears in the state, or increased publicity that such claims are sometimes paid from public funds. It is most likely, however, that the increase in total value of claims is due to a combination of all three factors.

More than ninety per cent of the stock killed by bears in Virginia is sheep. For this reason, only the value of the sheep sold in the counties where damage has occurred will be used to indicate the relative importance of this depredation.

The average annual loss amounts to 0.09 per cent of the value of the sheep sold in the year 1950 alone in those counties where livestock losses to bears have occurred (Dept. of Commerce, 1951).

Highland County claimed the highest losses ($2,559) of stock to bears in 1950. During this year approximately $315,000 worth of stock was sold in this county. Thus, the claimed losses to bears account for only about 0.8 per cent of the value of the livestock produced in this county in 1950.

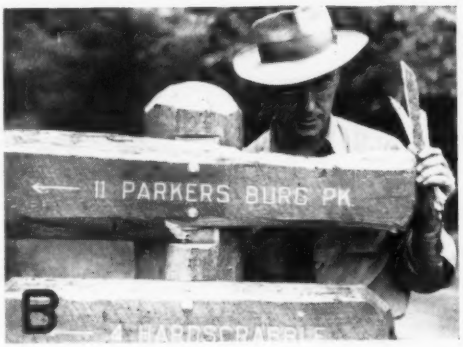
SUMMARY AND CONCLUSIONS

In Virginia, black bears are known to destroy such agricultural products as corn, livestock, apiaries, and orchards;

FIG. 2. Depredation by the black bear in Virginia. A. Most losses of livestock to bears occur in mountain pastures which extend well upon the ridges. B. In certain localities, bears destroy a large number of Forest Service signs and trail markers. C. Sheep constitute about ninety per cent of the livestock killed in Virginia. If a ewe is killed, the udder is normally the first portion eaten. D. Most bears kill their prey by a bite through the nape of the neck. This is a characteristic by which a bear kill may be definitely identified. E. Most of the corn damage by bears occurs in fields which border the Dismal Swamp. This particular field was not planted in corn in 1950 because of heavy bear damage the preceding year. F. Bears will often knock down and damage a number of corn plants as they move from one feeding area to another in a corn field. G. Many ears are bitten and ruined, but bears probably eat less than thirty per cent of the corn they damage. H. Bears occasionally take a quantity of corn from a field and pile it on the edge of the Swamp near the field margins.

A

E


II PARKERS BURG PK
B

F

C

G

D

H

and, occasionally, bears cause destruction of Forest Service trail markers and other signs. Bears are found in 35 of the 100 counties of Virginia and are limited to the Dismal Swamp section in the extreme southeastern tip of the state and to certain western mountainous counties. The estimated 1950 bear population is about 1500. In the Dismal Swamp area, most of the agricultural depredation by bears is in the form of corn destruction. It is estimated that the average annual loss of corn due to bears is approximately $2000, this damage being suffered by some thirty farmers. This average annual loss amounts to about 0.13 per cent of the value of the corn produced in this vicinity in 1950.

Practically all losses of stock due to bears occur in western Virginia and the killer bears are usually old males. Eleven western Virginia counties pay claims for stock lost to bears. Other adjoining counties sometimes have stock killed, but have no system of reimbursement from public funds. Approximately ninety percent of the stock killed is sheep. The average for the ten year period, 1941-1950, of claims for stock lost to bears in Virginia is $2,232. This average loss amounts to only 0.09 per cent of the value of sheep alone sold in the year 1950 in the counties where bear damage claims are paid. In Highland County, where claims are highest, the claims for bear-killed stock amounted to 0.8 per cent of the value of sheep sold in this county in 1950. It is evident from the above that the over-all extent of agricultural damage due to the black bear in Virginia is insignificant; however, the losses sustained by the individual farmer or livestock producer may be rather severe.

It is indicated that the control of agricultural damage caused by black bears is more of a local than a statewide problem. The elimination of the individual bear which is committing acts of depredation, rather than the inauguration of a general bear-control program, appears to be the most effective way of holding agricultural depredation by bears to a minimum in Virginia.

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Accepted for publication November 14, 1952.

HUNTING PRESSURE AND ITS EFFECT ON BOBWHITE QUAIL POPULATIONS IN EAST-CENTRAL TEXAS

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Errington and Hamerstrom (1935), in summarizing their data on winter survival of bobwhites (*Colinus virginianus*) on experimentally shot and unshot areas in Iowa, concluded that reasonable shooting is biologically sound. Hunting would be most advantageous in early fall in order that the kill might comprise birds from the doomed seasonal surplus. Comparison between bobwhite populations on hunted *vs.* protected areas in Oklahoma over a five-year period (Baumgartner, 1944) showed that reduction of the autumn population by hunting to approximately the normal breeding density did not result in a decline in numbers of birds from year to year.

Lehmann (1937) considers man as the worst "predator" of quail in Texas and points out that quail cannot be expected to increase in old ranges and spread to new areas as long as hunters endeavor to hunt out coveys to the last bird. Lay (1949) is of the opinion that hunting is not a serious problem because bobwhites shift around and restock overshot areas each spring. Hunting success becomes so low that hunting stops before breeding stock is seriously hurt on any large acreage. Evidence acquired during 1950 and 1951 in the Post Oak Region tends to indicate that hunting pressure does not lower the breeding stock below the normal carrying capacity of the land.

The dominant species in the upland Post Oak Region, which includes a portion or all of approximately 36 counties in east-central Texas, are post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*). Others found growing in association with these are water oak (*Quercus nigra*), hackberry (*Celtis occidentalis*), hickory (*Hicoria* spp.), and elm (*Ulmus* spp.). Thickets of yaupon (*Ilex* spp.), wild plum (*Prunus mexicana*), sumac (*Rhus copallina*), and stretchberry (*Smilax bona-nox*), coupled with weedy pastures containing goatweed (*Croton* spp.) and other weed species, provide excellent quail habitat in much of the Post Oak Region.

During 1950 and 1951, an ecological study was carried out in this region in an effort to determine the cause or causes of occasional extreme fluctuations in population numbers. Hunting pressure was thought to be a possible cause. Through the cooperation of quail hunters, and examination of climatological data for the region, the following information was obtained.

Cooperating were the Texas Game and Fish Commission, the Texas Cooperative Wildlife Unit, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service.

Effects of Climate on Hunting Success

Early reports (October-November) from landowners and hunters working their dogs in preparation for the

1951-1952 season (December 1-January 16) indicated large numbers of quail present, more in some cases than were noted in 1950. The fact was evident, however, that there was less protective cover in which the birds could hide. Reports from hunters made during the quail season indicated that about the same number of coveys were present as in the previous year, but with fewer birds in each. The adult-juvenile ratio in the winter of 1951-1952 was 1:1, the adults representing a large holdover of birds from the high population in 1950. The adult-juvenile ratio in the winter of 1950-1951 was 1:6, the large number of young resulting from a successful nesting season.

Most bird hunters considered the 1950-1951 and 1951-1952 quail seasons as average or even poor on the basis of the number of birds killed as compared with the number seen. The 1950-1951 season was characterized by very little rainfall with only 4.04 inches falling from August 1950 through January 1951. Evidently the ability of dogs to scent quail was seriously affected, and many coveys were overlooked or flushed before being detected. The number of birds killed during this season was low as compared with the number present.

The 1951-1952 hunting season followed a period of extreme drought (24.36 inches of rain in 1951), although rains in September and occasionally during the season dampened the soil, thereby increasing the dogs' ability to scent quail. The drought in the summer of 1950 had reduced grass and other ground cover but not to the point of almost complete bareness observed in many localities by late summer and fall of 1951. Coveys of quail located and pointed by dogs ran or flushed before hunters could approach within gunshot range.

It became almost impossible to locate single birds after the covey had flushed and scattered. Hunters reported quail making extremely long flights, some estimating distances between 300 and 500 yards. This long time-interval between flushing and alighting may have enabled the quail to run further or to hide. The birds' apparent uneasiness when found in open situations, resulting in quick flights and running, proved to be a compensatory factor for losses suffered indirectly from the drought. Probably a larger number of quail would have been harvested during the 1951-1952 season had it not been for the birds' habit of running from dogs and flushing without holding to a point.

DATA SUPPLIED BY HUNTERS

Approximately 30 hunters were contacted during the 1950-1951 and 1951-1952 quail seasons. They were asked to record the following information concerning each hunt: Hunter's name, date of hunt, county hunted, kill per hunter, total number of quail seen, total number of acres covered, number of hunters, number of hours of hunting, and cripples lost (Table 1).

This information, correlated with field observations and discussions with hunters, allows several conclusions to be drawn regarding hunting pressure in this region. Bobwhites nesting in the spring and summer of 1950 produced a high fall population as contrasted with a low population in 1951. Approximately one more bird was killed per hunt by each hunter in the 1950-1951 season than in that of 1951-1952, even though

TABLE 1.—COMPARATIVE DATA SUBMITTED BY HUNTERS DURING THE 1950–1951 AND 1951–1952 QUAIL SEASONS

Averages	1950–51	1951–52
Quail killed per hunter during each hunt.....	6.9	5.4
Number of hunts per hunter per season.....	6.6	7.6
Number of hunters in a party.....	2.0	2.0
Length of hunt (hours)...	3.8	3.9
Acreage covered per hunt	269.8	485.3
Number of birds killed per hunter each season.	36.6	33.5
Number of acres per quail (population density)...	5.54	12.2
Number of cripples lost per hunter on each hunt	—	.9

the hunter covered fewer acres per hunt in the former season.

A noticeable change was evident in the average number of acres per quail. In the fall of 1950, the population density of one quail per 5.5 acres was the highest recorded during the course of this study. The quail density (acres per quail) on the main research areas in Robertson County, based on October, 1950 census, was 8.2 acres per quail.[1] Possibly as a result of high mortality of young quail in the summer of 1951, the fall population density was about one bird per 12.2 acres, approximately half the density recorded for 1950.

HUNTERS AND HUNTING PRACTICES

Hunting pressure may be effective locally in reducing the number of birds below that which the area can support over the critical winter period. Most of the hunters who were contacted lived in Bryan and College Station and hunted in Brazos, Robertson, Madison, or Grimes County. In the majority of cases these men hunted the same areas each year. Usually the hunter's own discretion governs the number of birds he removes from a certain area during the hunting season.

Many of the hunters who assisted in the quail project were employed in positions that often allowed them several hours in the field each day. Most hunters averaged seven hunts a season with each man killing about 35 birds,[2] although two outstanding exceptions (not included in the averages) were noted. One of the two killed 237 quail in the 1950-1951 season, and the other killed 293 in the 1951-1952 season.

BAG LIMIT

Present hunting regulations permit a hunter to kill 12 quail per day but not more than 36 per week; 12 quail represent the number of birds in an average covey. Few hunters kill their limit of quail on each hunt. Another factor to be considered is the number of birds crippled or killed but never recovered. The number of birds recovered and those lost on 34 hunts during the 1951-1952 season were tabulated. Of 307 quail shot down during these hunts, 243 were recovered, the remaining 64 (20.8 per cent) being left in the field, crippled or dead. Probably many additional "feathered" birds and those not immediately affected by shot eventually suc-

[1] No hunting was permitted on the two 640-acre research areas during the 1950–1952 season. However, 16 bobwhites (20.5 per cent of the population on one area) were removed, evidently by natural causes, between October, 1950 and February, 1951.

[2] These figures are low since hunts in which no birds were killed or in which they were given to someone else were not recorded.

cumb to their wounds. This factor of birds lost should be taken into consideration when determining the number of quail that can be removed from an area and still leave a sufficient number of birds for the following breeding season.

It is believed the majority of sportsmen kill no more than the law allows. Several hunters reported having shot an occasional bird over their dogs during training periods before the season opened. This procedure may not be entirely without justification, but a practice of this type forms another "mortality factor" reducing bobwhite numbers.

F. M. Cowert [3] reported 20 hunters arrested in 1950 for killing quail in closed season; reports for 1951 included 8 arrests for killing quail in closed season and 14 for exceeding the bag limit. These probably represent only a few of the violations that actually occur during and between seasons.

The majority of local hunters can drive to their favorite hunting areas in one or two hours. Many profess to enjoy "getting out" and watching good dog-work and place these criteria above the actual killing of birds for meat. A reduction in the bag limit would not affect these individuals or those who rarely kill their limit, and it might help reduce the hunting pressure in certain local areas.

Despite illegal trapping and pot-shooting, exceeding the bag limit, and theoretically shooting each season all the birds allowed by law, a certain percentage of the wintering population during good and even average years evidently are able to withstand the hunting pressure and increase their numbers the following spring. However, the law makes no allowance for those years which are considered poor and when quail populations are at a minimum. Reduction of the bag limit in years of low quail populations may prevent overshooting in local areas.

[3] Director of Law Enforcement, Texas Game and Fish Commission.

THE HUNTING SEASON

Another factor of equal or greater significance is that of establishing a hunting season during the most favorable period of the year, both to the hunter and to quail. The quail season now runs from December 1 to January 16, inclusive. Special seasons and county variations exist, but they differ little from the designated general season.

Errington and Hamerstrom (1936) have expressed their belief, based on studies of hunting pressure and its effect on quail populations in Iowa and Wisconsin, that it would be most advantageous to have the hunting season early in the fall before the quail populations are reduced by natural causes. A similar opinion is expressed by Lay (1949) while presenting his ideas concerning the possibility of advancing the quail season in Texas.

Quail populations are at their peak following the summer breeding season, after which there is a constant decline in number until the breeding season commences the following spring. An early fall season will therefore provide a greater number of mature quail to hunters. Since the surplus fall populations will be reduced by one means or another to fit the late winter carrying capacity of the land, hunters could remove this early fall surplus before it is

lost to natural causes. It appears that the principal fault with a late season in Texas is that the fall surplus of quail has been partially removed before the season begins. With added hunting pressure, not only the remaining surplus but also the seed stock may suffer too great a loss in local areas during years of low populations.

Those opposing an early season claim that dry or warm weather and too dense ground cover seriously hinder hunting success. Grass and other cover may be heavier during the early fall, but a larger number of birds at that time certainly compensates for this slight disadvantage. Another factor favoring an earlier season is that the present hunting pressure on quail would then be distributed among those game species (deer, dove, and waterfowl) now having earlier seasons. Although a few hunters restrict their hunting activities to one species of game only, the majority hunt the several different game birds and mammals as they come into season.

SUMMARY

1. Through the cooperation of quail hunters, and by considering the effects of climate on hunting success, an effort was made to evaluate the effects of hunting pressure on quail populations in east-central Texas during 1950 and 1951.

2. For the Post Oak Region as a whole, hunting pressure apparently did not seriously reduce quail numbers during 1950 and 1951. The 1950-1951 and 1951-1952 hunting seasons were characterized by drought, and hunting success in many instances was poor, even though many birds were seen. Quail found in open pastures or fields appeared uneasy and would readily flush or run from dogs.

3. On the average, hunters killed only approximately one-half of the allotted 12 quail per day. Records kept on 34 hunts during the 1951-1952 season showed that 20.8 per cent of the quail shot down were never recovered.

4. The present quail season, December 1 to January 16, is considered unsatisfactory since much of the fall surplus has already been eliminated before the season commences. An earlier season—for example, from October 15 to November 30—would be more likely to provide better hunting and still retain a larger number of quail as seed stock.

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Accepted for publication August 24, 1952.

THE WILDLIFE SOCIETY

Report of the Secretary for the Year 1952

A definite growth in the Society has prevailed throughout the year just ended. With this growth, there has been a corresponding increase in the amount of secretarial work involved. Had the old membership classification plan been in effect, it is doubtful that the Secretary could have kept even reasonably abreast of the responsibilities connected with his office.

Routine work of the past year consisted of recording payments of dues, subscriptions, and orders for back issues of the Journal and the Cumulative Index; the placing of all such orders with the printer; making changes of address for members and subscribers; sending out membership application forms to members of the Membership Committee and applicants; invoicing subscribers and others for publications; answering a considerable number of inquiries from all over the world relative to the Society and its work; mailing out ballots on proposed Constitutional Revisions, on nomination of Regional Representatives for 1953, and on election of Officers and Regional Representatives for 1953; the tabulation of returned ballots; and other related activities too numerous to detail here.

At the close of December 1952, the Society had 11 Honorary Members, 10 Life Members, and 1,919 Annual Members. At the same time, there were 388 subscribers to the *Journal of Wildlife Management.*

As of February 28, 1953, the Society had the above-designated Honorary and Life Members, and a total of 1,591 Annual Members paid up for the calendar year of 1953. This is an increase of 177 Annual Members over this time in 1952.

Since December 1, 1952, a total of 205 new Members have been accepted. The flow of applications from new Members has been constant and continued right up to the close of February.

In our files at present, there are cards for 510 Members not yet paid up for 1953, as well as 138 subscribers who have not yet sent in their 1953 remittances.

The Secretary regretfully reports the loss of five Members by death in the past year, as follows: Henry C. Hahn, Kerrville, Texas; James N. Gowanloch, New Orleans, Louisiana; Cecil F. De LaBarre, Blacksburg, Virginia; W. L. Gambrell, Phoenix, Arizona; and Gordon P. Yohann, Spooner, Wisconsin. Information relative to other deaths is respectfully requested, so that our respects may be paid to their memory.

A total of nine Members submitted resignations effective December 31, 1952.

Ballots were mailed to all Members with regard to the Constitutional Amendment proposed at the 1952 Council and Society Meetings, providing that the President shall appoint all Committees for the Society.

The Nominating Committee for 1952 proposed officers for 1953, as follows: President—C. H. D. Clarke and Justin W. Leonard; Vice-President—Harlow B. Mills and W. C. Glazener; Secretary—Kenneth D. Carlander and Allen W.

Stokes. Secretarial nominations were subsequently omitted from the election ballot because of the appointment of George A. Petrides as Executive Secretary by the Council. Balloting on these nominees resulted in the election of C. H. D. Clarke as President and W. C. Glazener as Vice-President.

Mail balloting for nomination of Regional Representatives resulted as follows: Region I—Roger Latham and Durward L. Allen; Region II—Leonard E. Foote and Edward E. Hueske; Region III—Thomas R. Evans and Donald W. Douglas; Region IV—Ralph Hill and Lee E. Yeager; Region V—W. B. Davis and F. M. Baumgartner; Region VI—A. Starker Leopold and J. B. Lauckhart; Region VII—C. D. Fowle and Ian McT. Cowan.

Results of the election balloting for Regional Representatives gave the following: Region I—Roger Latham; Region II—Leonard E. Foote; Region III—Thomas R. Evans; Region IV—Lee E. Yeager; Region V—F. M. Baumgartner; Region VI—A. Starker Leopold; and Region VII—C. David Fowle.

Orders for back issues of the *Journal of Wildlife Management* and the Cumulative Ten-Year Index have continued through the year. At present, the publisher's stock of 11 different numbers has been exhausted. Seven other numbers are down to 20 or less. Sufficient copies of the Index remain to supply two or three more years' demands, it appears.

Special credit is due Dr. George A. Petrides, and his Membership Committee, and Regional Representatives for the recent fine response to their efforts in securing new members. A few other individuals have been active in this connection through the past year, as examples of personal interest in Society growth. The Society owes a vote of thanks both to them and to the Sage of Artemisia (See *Wildlife Society News*, February 1953, page 4).

The Secretary wishes to extend his thanks to the Council Members, Members of the Society, and other persons for their many helpful suggestions through the course of the past two years. He gratefully acknowledges their courtesies and tolerance in not a few instances wherein oversight on his part caused them inconveniences of one kind or another.

For secretarial assistance during 1952, the Secretary is particularly indebted to Mrs. Martha W. West and Mrs. Lisa Engeling, Austin, Texas. These ladies join me in wishing for the Society further growth and success.

Respectfully submitted,

W. C. GLAZENER, *Secretary*
March, 1953

REPORT OF THE TREASURER FOR THE FISCAL YEAR

March 1, 1952 to February 28, 1953

Following is the annual report of the Treasurer of the Wildlife Society Inc. for the fiscal year March 1, 1952 to February 28, 1953. This year, President Daniel L. Leedy authorized the Treasurer to have made a professional audit of the Treasurer's records. This was accomplished by Alice M. Blanchard, C.P.A., Albany, New York. Following are Exhibits A and B which formed the accounting part of the auditor's report.

Exhibit A: *Balance Sheet*

ASSETS			*AMOUNTS*	
Cash—Current Account				
National Commercial Bank & Trust Co.			$15,171.79	
Savings Account				
Emmigrant Industrial Savings Bank.....			8,091.11	$23,262.90
Dues Receivable—In Process of Collection.....				20.00
Securities—Market Values				
22 Shs. State Street Investment Corp.....			1,567.50	
30 Shs. Loomis-Sayles Mutual Fund, Inc. ...			1,137.90	
(The above shares are all common stock)				
U. S. Government—12 year bonds				
Par	*Cost*	*Date of Purchase*		
$ 500.00	$ 370.00	April 1947.....	476.00	
500.00	370.00	April 1947.....	476.00	
500.00	370.00	Sept. 1948.....	474.00	
500.00	370.00	Sept. 1948.....	474.00	4,605.40
$2000.00	$1480.00			
		Total Assets.....		$27,888.30
LIABILITIES AND NET WORTH				
Liabilities.....				None
Net Worth.....				$27,888.30
		Total Liabilities and Net Worth.....		$27,888.30

Exhibit B. *Income and Disbursements*

ITEMS	*AMOUNTS*
Balance—Current Account—March 1, 1952.....	$18,465.87

Income—Dues		$11,383.79	
Subscriptions		1,896.88	
Back Issues—Journal		1,830.80	
Dividends, Interest		330.92	
Sales—Index		183.00	
Sales—Reprints		63.10	
Sales—Michigan Overrun		20.00	
Gifts		105.00	
Payments on Life Memberships		100.00	15,913.49
			$34,379.36
Disbursements			
Journal—Printing and Mailing	$8,707.27		
Insurance on stock	42.12	8,749.39	
Mailing Back Issues		197.15	
Editor's Expenses		190.38	
News—Printing	600.14		
Mailing	208.56	808.70	
Printing—General Supplies		382.30	
Postage—General		325.75	
Express		90.42	
Treasurer's Expenses		27.75	
Clerical Assistance		71.25	
Refunds, Bank Charges, Collection Fees		129.07	
Contributions		50.00	
Award Engraving		4.28	
Miscellaneous		130.54	
Transferred to Savings Account		8,000.00	
Conference Expenses		25.59	
Repairs—Equipment		25.00	$19,207.57
Balance—Current Account—February 28, 1953			$15,171.79

Insurance on the stock of Journals held at Cayuga Press, Ithaca, New York is carried in two policies with The Continental Insurance Company as follows:

Policy No.	*Expir. Date*	*Amount*	*Coverage*
SL 26851	5/5/53	$6,000.00	Sprinkler leakage
SL 12204	5/5/53	6,000.00	Fire and E. C.

The two policies carry a 90% co- insurance clause.

Respectfully submitted,

E. L. CHEATUM, *Treasurer*

REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council convened at 7:00 P.M. on March 8, 1953, in the Statler Hotel, Washington, D. C. Members in attendance were Daniel W. Leedy, President; Warren W. Chase, Past President; Paul D. Dalke, Vice-President; E. L. Cheatum, Treasurer; W. C. Glazener, Secretary; Durward L. Allen, Representative, Region I; Arnold O. Haugen, Representative, Region II; Thomas R. Evans, Representative, Region III; M. S. McMurtrey, Acting Representative, Region IV; W. B. Davis, Representative, Region V; A. Starker Leopold, Representative, Region VI; and C. David Fowle, Representative, Region VII. Members of the Council for the new year were also present to facilitate an orderly transfer of Society responsibilities.

Items of business discussed, and action taken thereon, follow.

Constitutional amendments proposed by the Committee on Constitutional Revision were approved for submission to the Society. These proposals will appear in an early issue of the *Wildlife Society News* and subsequently mail ballots will be provided for action thereon.

The Council accepted the resignation of Gustav A. Swanson as Editor of the *Journal of Wildlife Management*, and appointed Oliver H. Hewitt as his successor.

Henry S. Mosby was re-appointed Editor of the *Wildlife Society News*.

Hereford Naylor Elliott was re-appointed as Trustee, to serve until 1956.

The Council approved publication of the 1952-53 Society Directory as a part of the Journal for October 1953.

On recommendation a report of the Archives Committee was approved and the committee discharged with thanks for its service. Old file material having historical value will be sent to the Executive Secretary for future use.

Discharge of the Finance Committee was approved; there being no active need for such committee at this time.

The Council approved a budget of $12,500.00 for the period of March 1, 1953 to February 28, 1954, with items as follows:

Journal of Wildlife Management	$9,000.00
Wildlife Society News	750.00
Society Directory	400.00
Society Employment Desk	50.00
Natural Resources Council of America	50.00
Bonds—for Executive Secretary & Trustees	50.00
Honorarium for Executive Secretary	600.00
Clerical help for Executive Secretary	600.00
Travel Expense for Executive Secretary	200.00
Office supplies, postage, express, etc.	550.00
Contingency Fund	250.00
	$12,500.00

The Council authorized the transfer of $2,000.00 to the Permanent Trust Fund for investment as recommended by the Trustees; said amount to come from a surplus in the checking account.

Payment of $50.00 to Miss Shirley Albrecht was approved as a token of

appreciation for her valuable assistance to the Editor of the *Journal of Wildlife Management* through the past four years.

The Council approved a recommendation that an annual audit by a C.P.A., be arranged as a routine step on the part of the Executive Secretary.

A proposal that the Society utilize advertising space in the Clements Memorial Issue of the *Journal of Ecology* did not pass.

The Council tabled a proposal that the *Journal of Wildlife Management* carry advertising matter.

The Council opposed affiliation with the AIBS at this time.

The proposal to exchange the *Journal of Wildlife Management* for publications from certain recognized institutions was tabled by common consent.

The Council disapproved the matter of having the membership addressograph plates used by commercial organizations or individuals for the purpose of circularizing Society members.

The Council approved appointment of a committee having authority to make an annual award in the field of Wildlife Conservation Education.

The Council unanimously approved designation of C. R. Gutermuth and Kenneth A. Reid as Honorary Members, subject to Society confirmation.

Resolutions proposed by the Resolutions Committee were acted upon; those approved by the Council will be presented by the Committee at this annual business meeting.

Respectfully submitted,
W. C. GLAZENER, *Secretary*

MINUTES OF THE ANNUAL MEETING

The seventeenth annual business meeting of The Wildlife Society was called to order by President Daniel L. Leedy at 8:00 P.M., March 9, 1953, in the Statler Hotel, Washington, D. C. Approximately 200 members were present.

Reading of the minutes of the 1952 business meeting was waived since they appeared in the *Journal of Wildlife Management* for July, 1952.

The report of the Secretary and the report of the 1953 Council meeting were read and approved. The latter included a recommended budget for the 1953 Society year.

The Treasurer's report was read and approved as audited by Alice M. Blanchard, C.P.A.

Reports from regions and sections were approved as prepared by the following:

Region I (Northeast) Durward L. Allen

Region II (Southeast) Arnold O. Haugen

Region III (North Central) Thomas R. Evans

Region IV (Great Plains) Levi L. Mohler

Region V (Southwest) W. B. Davis

Region VI (West) A. Starker Leopold

Region VII (Canada) C. David Fowle.

The foregoing reports will appear in an early issue of the *Wildlife Society News*.

The Society unanimously approved designation of C. R. Gutermuth and Kenneth A. Reid as Honorary Mem-

bers, upon recommendation of the Council.

Representatives of various Committees presented their respective reports. Those containing material of special significance appear hereafter in the *Journal of Wildlife Management*. Presentation of reports was by committee representatives, as follows:

Archives—P. F. English

Awards—Fisheries Publication—Robert S. Campbell

Awards—Terrestrial Publication—W. F. Crissey

Employment—Lansing A. Parker

Professional Standards—Norman G. Wilder

Research Needs—A. Starker Leopold

Wetland Management—Hayden Olds

Nomenclature—William H. Elder

The Society waived reading of proposals for Constitutional Revisions because that report will appear in the *Society News* prior to distribution of voting ballots by the Executive Secretary.

Five resolutions presented by Kenneth Hungerford were approved, as follows: (1) Urging enactment of H. R. 1972 (Baker Bill) by the Congress; (2) Approval of S. 71 (Robertson Bill) now under consideration by the Congress; (3) Recommending revision of mining laws to take into consideration wildlife, recreational, and related nonmineral values; (4) Expression of thanks to the Wildlife Management Institute for its encouragement and support of wildlife research and management; (5) Expression of thanks to the Wildlife Management Institute, Society Program Committee and the Statler Hotel for their efforts in making the 18th North American Wildlife Conference an outstanding affair.

A vote of thanks was given Gustav A. Swanson for his contribution as Editor of the *Journal of Wildlife Management*.

Respectfully submitted,

W. C. GLAZENER, *Secretary*

REPORT OF AWARDS COMMITTEE, TERRESTRIAL PUBLICATIONS

March 1953

As recipient of the Wildlife Society's Award for the best terrestrial publication for 1952, the Committee has selected Robert L. Patterson's, "The Sage Grouse in Wyoming." In choosing this publication, the Committee was governed by the quality and originality of the work and the significance of the contribution to the broad field of wildlife biology and conservation, its coverage of the subject matter, and the effectiveness of presentation. It is with sincere pleasure that the Committee makes this recommendation for the Award, and it is hoped that this recognition of achievement will stimulate and inspire further high-quality work in the biology of native wild animals.

In recognition of additional outstanding terrestrial publications the Committee recommends for Honorable Mention the following:

Robert P. Allen—"The Whooping Crane"; Joseph A. Hickey—"Survival

Studies of Banded Birds"; A. Starker Leopold, Thayne Riney, Randal McCain and Lloyd Tevis, Jr.—"The Jawbone Deer Herd"; William M. Longhurst, A. Starker Leopold and Raymond F. Dasmann—"A Survey of California Deer Herds, Their Ranges and Management Problems"; Harold S. Peters and Thomas D. Burleigh—"The Birds of Newfoundland."

Several nontechnical publications were brought to the attention of the Committee. Since they do not represent original, scientific contributions, they were not considered for the Award. However, they are so outstanding in conservation education that they deserve Special Mention. As significant contributions in general conservation, the Committee wishes to recognize: (1) R. W. Eschmeyer's children's series, "Freddy Fox Squirrel," "Bob White," "Charley Cottontail," etc., (2) Jack A. Stanford's "Whirring Wings—The Bobwhite Quail in Missouri," and (3) Charles W. Schwartz's film "Bobwhite Through the Year." Although honoring a film may seem unorthodox to some members of the Society, the Committee felt that recognition should be given to the outstanding contribution made by this film to wildlife-conservation education. No commercial films were considered for this recognition. Those who have seen the film will readily concede that its impact on American society will be considerable and that it will accomplish much in directing public thinking toward sound principles of biology, conservation, and wildlife management.

Respectfully submitted,

WALTER F. CRISSEY
VICTOR E. F. SOLMAN
BEN GLADING
HELMUT K. BUECHNER
IAN MCTAGGART COWAN,
Chairman

REPORT OF THE AWARDS COMMITTEE, FISHERIES PUBLICATIONS

March 1953

The Committee was unanimous in the decision that the award for the most outstanding fisheries paper for the biennium 1951-1952 should go to Dr. Hardin F. Taylor both for his contribution as editor of the "Survey of Marine Fisheries of North Carolina" and for his authorship of "Economics of the Fisheries of North Carolina" which appeared as Part III of the Survey of Marine Fisheries of North Carolina, 1951. This work, which is based upon the experience and observations of the author and upon statistical data of the U. S. Fish and Wildlife Service, extends beyond the limitations of the title to include the economics of the fisheries of the United States.

The committee wishes to submit the following citations as worthy of Honorable Mention:

Frank Jobes, for his monographic work on yellow perch as evidenced in his treatise, entitled, "Age, Growth and Production of Yellow Perch in Lake Erie," Fishery Bulletin 70, U. S. Fish and Wildlife Service, 1952.

Paul G. Barnickol and William C.

Starrett for their intensive study of the fishery of the Mississippi River: "Commercial and Sport Fishes of the Mississippi River between Caruthersville, Missouri and Dubuque, Iowa." Bull. Ill. Nat. Hist. Surv., Vol. 25, Art. 5, 1951.

R. W. Eschmeyer for his successful effort in conservation education in fisheries as illustrated by three small books: "Billy Bass," "Tommy Trout," "Bobby Bluegill."

Vernon C. Applegate for his detailed study of the life history of a fish under the title "Natural History of the Sea Lamprey (*Petromyzon marinus*) in Michigan." Special scientific report: Fisheries No. 55, U. S. Fish and Wildlife Service. (Although this report bears the publication date 1951, it was not distributed until about March of 1952.)

The method of publication of Applegate's study leads the committee to go on record as stating that (1) Applegate's investigation was outstanding but the form of publication and restricted distribution handicapped their judgment; (2) there is a very real problem as to whether or not the manner of publication of this document by the U. S. Fish and Wildlife Service constitutes publication at all; and (3) they urge that all possible steps be taken to improve this condition in the Service.

Respectfully submitted,
GEORGE W. BENNETT
PAUL H. ESCHMEYER
CARL L. HUBBS
KARL F. LAGLER
ROBERT S. CAMPBELL, *Chairman*

REPORT OF THE NOMENCLATURE COMMITTEE

Your Committee on Nomenclature has very little to add to the report of the committee in 1952. We should like to reiterate some of the recommendations which they made.

The Committee on Nomenclature for 1951 prepared a preliminary glossary of wildlife terms which was passed on to the 1952 committee and in turn was made available to us. The present committee feels that this glossary would require numerous changes and additions before it would be acceptable to this Society. The present committee did not consider themselves adequate to this task, but they feel that a standardization of terminology in the field of Wildlife Management would be a worthwhile contribution to the Society.

This committee recommends that a change be made in both its title and its scope; that it be titled "Terminology Committee" and that it be charged with the preparation of a glossary that could be accepted as the standard for terminology in the field of Wildlife Management.

It is further recommended that this committee should include authorities in the various specialties within the scope of wildlife management and that it be established as a standing committee for the duration of the task.

Respectfully submitted,
ROLLIN H. BAKER
CARLTON M. HERMAN
EUGENE P. ODUM
PHILIP L. WRIGHT
WILLIAM H. ELDER,
Chairman

ENROLLMENT, GRADUATION, AND JOBS

REPORT OF THE EMPLOYMENT COMMITTEE

March 1953

Because of the continuing interest that the membership has shown in the statistics on enrollment, number of graduates, and their employment, the Employment Committee again made a canvass of schools offering professional training in wildlife management. Past surveys were published in the *Journal of Wildlife Management* under titles, "It Is Time to Take Stock," 14(2): 237-242, "More Stock Taking," 15 (3): 317-322, and "Supply and Demand," 16 (3): 358-365. Last year and again this year the committee solicited information concerning immediate job openings and long-range employment plans from state, provincial, and federal game and fish agencies. The committee is very grateful for the cooperation extended by the schools and employing agencies that furnished the information for this survey.

ENROLLMENT

The most perplexing problem which the committee has faced since the inception of the survey is that of getting complete coverage of all schools turning out "wildlife" students. There is yet no minimum standard by which to define "fish, game or wildlife graduates." As a result new schools are added each year and some are dropped. This year questionnaires were sent to 54 colleges and universities in Alaska, Canada, and the United States. All but two replied. Ten new schools, including some that did not reply last year, were added to the mailing list and 14 were dropped. The schools canvassed this year are grouped in the table based upon information furnished by their representatives.

A considerable number of the schools do not offer bachelor degrees in fish or game management. In many institutions the students do not declare their major until their sophomore, junior, or senior year. Therefore, the undergraduate total of 1,358 must be considered the minimum figure for the current enrollment. The graduate students were reported to be 434, with 308 working on masters' and 126 on doctors' degrees. Last year undergraduates totalled 1,271 and graduates 486.

To arrive at comparable data for the 1951-52 and the 1952-53 enrollments, the reports for 40 institutions responding to both surveys were totalled. Last year there were 1,297 undergraduates compared to 1,243 for current enrollment. Graduate students also dropped from 475 to 395. The totals for these schools were 1,772 in 1951-52 and 1,638 this year. Thus, although the total number of students this year slightly exceeded the figures of a year ago, the comparison between the data for the schools reporting both years reflects a further decline in enrollment for the fourth straight year. This amounted to four per cent for undergraduates and 17 per cent in the graduate schools. The decline in advanced degree students is the first recorded for some time.

DISTRIBUTION OF ENROLLMENT BY CLASSES AND SCHOOLS

SCHOOL	UNDERGRADUATES					GRADUATES		
	Fresh.	Soph.	Junior	Senior	Total	Masters	Ph.D.	Total
Alabama Polytech	4	3	4	7	18	8	–	8
Alaska, Univ. of	2	5	1	2	10	8	–	8
Arizona, Univ. of	3	2	4	4	13	5	–	5
Arizona, State College	1	–	1	1	3	–	–	–
British Columbia, Univ. of	*	*	3	5	8	5	8	13
California, Univ. (Berkeley)	–	–	15	11	26	3	6	9
Colorado A. and M.	40	10	10	11	71	8	–	8
Connecticut, Univ. of	3	3	4	4	14	5	–	5
Florida, Univ. (School of Forestry)	*	*	3	3	6	2	–	2
Georgia, Univ. of	*	*	4	4	8	4	4	8
Humboldt State College	10	12	22	24	68	–	–	–
Idaho, Univ. of (1)	*	*	6	2	8	7	–	7
Iowa State College	*	*	6	5	11	6	7	13
Louisiana State Univ. (2)								
Maine, Univ. of	–	11	11	10	32	5	–	5
Massachusetts, Univ. of	15	12	12	9	48	–	–	–
Miami, Univ. of (Florida)	–	–	–	2	2	13	–	13
Michigan State College	24	20	38	32	114	16	5	21
Michigan, Univ. of	7	6	14	13	40	16	16	32
Minnesota, Univ. of	14	10	9	6	39	4	2	6
Missouri, Univ. of	8+	12+	9	12	41+	16	5	21
Montana State College	9	7	3	5	24	12	–	12
Montana, State Univ.	1	4	6	20	31	8	–	8
Nevada, Univ. of	2	2	3	3	10	1	–	1
New Hampshire, Univ. of	*	2	4	2	8	–	–	–
New York State Coll. of Agri. (Cornell)	25	13	15	15	68	14	19	33
N. Y. State Univ. (Syracuse)	**	**	**	**	**	11	5	16
North Carolina State	8	7	8	10	33	–	–	–
Ohio State Univ.	*	*	17	19	36	15	4	19
Oklahoma A. and M.	12	11	8	9	40	9	11	20
Oklahoma, Univ. of	–	–	1	–	1	9	7	16
Ontario Agri. College	–	–	1	–	1	–	–	–
Oregon State College	45	52	16	43	156	18	1	19
Penn. State College	**	**	**	**	**	6	–	6
Purdue Univ.	4	–	–	–	4	–	–	–
Rutgers Univ.	*	3	2	1	6	1	1	2
San Jose State College	15	5	5	5	30	–	–	–
South Dakota State	22	6	7	6	41	–	–	–
So. Illinois Univ.	*	*	4	6	10	9	–	9
Texas A. and M.	22+	17+	6	10	55+	3	2	5
Utah State College	14	11	8	15	48	18	5	23
Virginia Polytech	*	*	*	4	4	9	2	11
Washington State College	18	15	12	13	58	5	2	7
Wash. Univ. (School of Fisheries)	31	14	11	29	85	12	11	23
West Virginia, Univ. of	*	*	2	6	8	–	–	–
Wisconsin, Univ. of	–	–	–	2	2	9	3	12
Wyoming, Univ. of	4	2	3	10	19	8	–	8
TOTALS (47 schools)	363	277	318	400	1358	308	126	434

* Not designated
** No undergraduate in wildlife
(1) New curriculum provides for B.S. in fish and wildlife
(2) No course work in 1952-53

Duke Univ.	One course in the fields							
Illinois, Univ.	Only part in the fields		13	8	21	15	2	17
Kansas Univ. Premed. & some wildlife	*	*	20	16	36	11	19	30
Rhode Island Univ. Zoology or Ecology	*	*	1	1	2	–	–	–
Toronto Univ. Zoology majors	**	**	**	**	**	–	–	15

No replies from: University of Kentucky
University of Maryland

Comparing the undergraduate classes for all schools reporting in 1950-51, 1951-52, and 1952-53; the freshman figures were 21, 21, and 27 per cent respectively. Sophomores' percentages were 28, 23, and 20. Juniors amounted to 25, 28, and 23. The percentages of seniors were 26, 28, and 29. It must be remembered that the figures for freshmen and sophomores especially are low because in many schools they are not designated as "wildlife students." However, the comparison by years for each class is interesting. Until this year the figures reflected the upsurge in enrollment due to G. I. benefits.

The ratio of undergraduates to advanced students showed a very favorable trend toward more graduate studies until this year when the ratio again widened. Figures for the past four years are as follow: 1949—4.6 undergraduates to 1 advanced student; 1950—3.1 to 1; 1951—2.6 to 1; and this year 3.1 to 1.

GRADUATES AND THEIR STATUS

Forty-eight schools reported 568 students graduating during the school year ending September 30, 1952. This was a decided increase over the last period when 495 were reported but is under the 633 recorded in the term ending September 30, 1950. They were divided as follows: 374 Bachelors', 165 Masters', and 29 Doctors' degrees. The previous year's figures were 335, 137, and 23.

Subsequent to graduation, the 1951-52 crop dispersed as follows: 127 of the Bachelors, or slightly over 34 per cent found employment in fish and game fields (including teaching). This is a decline of one per cent from the preceding year. There has been a decrease in this type of employment for each of the past three years. For the second consecutive year almost a fourth returned for further schooling. Military services took 20 per cent or double the percentage of last year. Seven per cent found other employment, of which two per cent were in forestry, public health, or other related fields. The status of more than 14 per cent was listed as "unknown."

Nearly two-thirds (64 per cent) or 106 of those receiving their Master degrees were able to obtain work in the fields they had trained for, including wildlife teaching. This is a somewhat brighter picture than a year ago when 55 per cent found this type of employment. Nearly 19 per cent returned to school, which is the same percentage as the previous year. Only three per cent were claimed for military service, which is half of last year's percentage. Almost 11 per cent found other employment, of which four per cent was in related fields. The "unknowns" accounted for nearly four per cent.

Those receiving Doctor's degrees were divided as follows, with respect to securing employment: 79 per cent in fish and wildlife work, including teaching and 21 per cent were in other types of work, including 14 per cent teaching in unrelated fields. Teaching of all types attracted 60 per cent of the class.

As would be expected, state and provincial game and fish agencies offered the best source of employment. Seventy-one per cent of the year's graduates were reported to be working in these departments. Various federal agencies, including those offering foreign assignments attracted 13 per cent of the

graduates employed in the fish and game fields. Teaching fish, game, or wildlife courses, including research, accounted for nine per cent. Only a small number, 15, or six per cent, were reported to be engaged in private fish or game employment.

Of interest is the breakdown by types of work in the wildlife fields. As has been the case for at least the past two years, the majority were employed in game work. One hundred and twenty, or 47 per cent of 256 graduates in fish and game work were employed as game technicians as compared to last year's 45 per cent. These were split into 39, or 15 per cent of the total in game research, and 81, or 32 per cent of the 256 were employed in game management. Fisheries technicians totalled 93, or 36 per cent, which is an increase from last year's 32 per cent. This year 46, or 18 per cent of the total were employed in fisheries research, while 47, or slightly more than 18 per cent were in fisheries management work. Nine, or four per cent wound up in combination fish and game positions compared to 17, or eight per cent of the total last year. The number in law enforcement work totalled five, or two per cent, which is a decrease from the six per cent of last year. Public relations work drew seven, or three per cent, and 22, or nine per cent, were engaged in teaching fish or wildlife courses.

THE JOB OPENINGS

Following last year's study the committee again circularized the state, provincial, and federal agencies which are known to employ fish and wildlife technicians. The committee felt that real service could be rendered to those members who are looking for new employment by publishing a list of current openings. All of the state fish and game departments, two of the Canadian provinces, the Alaska Game Commission, the Canadian Wildlife Service, the U. S. Fish and Wildlife Service, the U. S. Forest Service, and the Soil Conservation Service responded.

To make the survey of immediate value, the job openings were printed in the February issue of the *Wildlife Society Newsletter*. By way of recapitulation the employing agencies reported need for 127 or more fish technicians for permanent jobs and 252 or more for temporary openings. In the game field the permanent positions totalled at least 118 and temporary jobs more than 152. In addition, the administrators estimated they would need at least 218 conservation officers or wardens. Vacancies in the departments' public relations work totalled 22. Thus, without knowledge of the needs in other state and federal agencies, colleges, and in private fields, the committee was able to report at least 889 openings for which fish or wildlife trained men might qualify. Of these 485 were permanent positions. Compared to last year's 581 permanent openings, the employment picture does not look as rosy. However, if it can be assumed that the percentages of the last year's class of seniors, Masters, and PhD.'s entering the wildlife field can be applied to this year's enrollment in those classes, a figure of 414 is "guesstimated" to be the number of students who will be looking for jobs. Thus, the number of openings compares favorably with the potential supply. However, a word of caution should be added. At

least 218 of the openings are for conservation officers for which the administrators frequently make selections from nontrained wildlife men. Also, many of the states and all of the federal positions require entrance examinations and appointments are made from lists of eligibles.

For the benefit of those who desire to look ahead to future employment in fish and wildlife work, the committee asked the administrators for their long-range employment outlook. Almost two-thirds, or 37 administrators felt there would be an increased need for trained fish technicians, while 20 or more than a third expected about the same need for these men. Eighty-five per cent of the administrators last year felt there would be an increased need for fish men.

The game phase will not be so bright. Only 22, or 29 per cent, felt there will be an increased need for technicians trained in this field. Thirty-four, or 60 per cent, offered the opinion that needs would remain about the same, while one expected a decrease. There is a definite slackening off in the demand for game technicians, for more than half of the administrators last year reported an increased need for these men in the long-range outlook. Considering the future needs for conservation officers or wardens, 43 per cent of the administrators felt there would be an increasing demand. Last year 55 per cent gave that optimistic answer. Another 53 per cent thought that needs would remain the same as compared to 45 per cent for last year.

The committee had been requested to learn what value the administrators placed on letters of recommendation written by the instructors in behalf of their students. Admittedly it is difficult to frame the question to get an unqualified answer. Many of the administrators rightly "hedged" by saying "it depends on if I know the writer." Yet, in spite of the difficulty of giving a positive answer, 26 of the administrators indicated they give major consideration to the teachers' recommendations. Another 34 replied it was given some consideration, and one frankly advised he disregarded the letters.

EMPLOYMENT SERVICE

Acting on the recommendation of last year's Employment Committee, the Council authorized the operation of an employment service at the 1953 North American Wildlife Conference. Preliminary arrangements involved advising the fish and game administrators and the Society membership that this service would be available. Also assistance was given by the Wildlife Management Institute in the form of advanced publicity and arrangements for space during the conference.

As a result 78 personal data memorandums were received by mail and 64 more job seekers registered during the conference. At present the committee has a file of 142 applications for jobs. All types of fish and game experience are represented. These include, in addition to the more common backgrounds, such categories as writing, wildlife art, disease and nutrition research, and conservation education. All degrees of experience are represented, ranging from students about to graduate to some of the better trained fish and game men in the country.

As would be expected, there were more job seekers than openings and

the committee does not have accurate records of the number of men who received jobs as a result of the employment reference service. At least 75 personal interviews were arranged during the conference and several administrators took lists of prospective employees home for further consideration. The committee wishes to publicly acknowledge the services rendered by LaVerne Brugger, United States Civil Service Commission, Washington, D. C. He volunteered to assist at the employment desk and spent long hours there on his own time and at his own expense.

CONCLUSIONS AND RECOMMENDATIONS

By comparing last year's data with current figures for the 40 colleges reporting for both periods, it was found that there was a continuing decline in the enrollment in fish and game curricula. Leveling off in employment, graduation of the G. I. students, and the heavy military demands account for this condition. This is fortunate for the number of permanent job openings reported by the fish and game administrators dropped from 581 last year to 485 during the current survey. The supply and demand appear to remain nearly in balance. However, the long-range employment outlook points to very little expansion. This is a legislative year in most of the states, and the watchword is economy and reduced spending. As a result, the administrators are moving cautiously on hiring added personnel.

One bright spot can be reported though—during the conference many of the school representatives reported they had graduate fellowships available. Most of these are going begging at the present time.

The committee recommends that the job application files be maintained during the coming year so that employers may have ready access to the names of individuals desiring employment. The employment reference service was operated on a trial basis and the committee members admittedly were rank amateurs in this operation. Yet considerable interest was expressed by employers and job applicants alike. Therefore, the committee recommends that the employment service be undertaken at the next North American Wildlife Conference. (By Council action funds have been provided to carry out this recommendation.)

Respectfully submitted:

MERLE A. GEE
LAURENCE E. RIORDAN
WILLIAM F. SIGLER
HAROLD V. TERRILL
LANSING A. PARKER,
Chairman

REPORT OF THE COMMITTEE ON RESEARCH NEEDS

March 1953

In 1952 this Committee submitted a report pointing out the current tendency in wildlife research to emphasize short-term, superficial, or "practical" lines of inquiry at the expense of more laborious and exacting studies of fundamental ecological problems (Jour. Wildl. Mgt., 16(3): 365-369). It was acknowledged that short-term investigations, which are widely utilized to guide and later to evaluate management programs, are looked upon as corollaries of management and should not obscure the need for research at deeper levels. The need for balance in research programs has been pointed out before (Trans. N. Amer. Wildl. Conf., 1948, 13: 44-48) but seemingly still needs emphasis.

The total research undertaking in the wildlife field is sponsored by many agencies, which may be divided into two principal categories:

1. The Wildlife Administrative Agencies—mainly State Fish and Game Departments but including also the Fish and Wildlife Service, National Park Service, Forest Service, and Soil Conservation Service. The largest segment of research carried on by administrative agencies finds support from Pittman-Robertson funds, and more recently from Dingell-Johnson funds in the fields of fisheries.

2. The Teaching and Research Institutions—Universities, Cooperative Wildlife Research Units, Foundations, Institutes and privately financed organizations. The administrative agencies, specified above, contribute in many instances to the operational costs of these institutions.

There seems to be a wide-spread feeling in the profession that administrative agencies should specialize in short-term studies keyed directly to current management operations, whereas the teaching and research institutions should delve into more fundamental studies that might or might not prove to have immediate practical application. It is our purpose to appraise the extent to which this division of the field is actually practiced and secondly to re-examine the basic premise of such allocation of functions.

Perhaps the best available index to the types of research conducted by administrative agencies is the *Pittman-Robertson Quarterly*. An analysis of how P-R research funds are spent will serve to illustrate what sorts of studies are currently in vogue among State Fish and Game Departments. We have attempted to set up a sample cross-section of research effort by selecting one type of game animal, the deer (both *Odocoileus virginianus* and *O. hemionus*), and classifying the deer studies reported in the Quarterly for the five-year period 1948-1952. This was done in the following manner. A list was compiled of 22 types of deer studies, and the reports from each state or territory were searched for the five-year period to see how many of these types of research were being pursued. If a given activity was reported even once (for example, operation of checking stations to obtain kill data) it was

recorded as part of that State's research program. Only designated research projects (R series) were included in the compilation. The record, summarized from reports of 35 states and Alaska, follows:

TYPES OF DEER RESEARCH REPORTED IN PITTMAN-ROBERTSON QUARTERLY, 1948-52

A. Studies of a practical nature, directly correlated with management.	Number of states or territories participating.
1. Range surveys to measure local forage conditions	21
2. Distributional surveys of deer	14
3. Assembling kill statistics (tag returns, post cards, etc.)	14
4. Operation of checking stations (kill data, weights, and measurements, etc.)	14
5. Surveys of crop damage, experimental control	14
6. Composition counts to determine buck:doe:fawn ratios	13
7. Census of local deer populations	13
8. Trapping and transplanting breeding stocks	9
9. Experiments in supplementary feeding of starving deer	7
10. Experimental salting	2
B. Studies of life history, ecology, physiology, population dynamics	
11. Measure of natural losses (starvation, predation)	8
12. Studies of browse ecology (exclosures, clipping experiments, etc.)	7
13. General life history observations on daily and seasonal behavior patterns, use of cover types, water needs, time of breeding and fawning, etc.	5
14. Food habits study by stomach analysis	5
15. Measurement of population response to habitat changes (logging, fire, water development, etc.)	4
16. Studies of parasites and disease	4
17. Tagging and releasing deer to study movements, longevity, turnover	3
18. Study of rates of ovulation, implantation and parturition	3
19. Feeding studies with penned animals	3
20. Chemical analysis of natural deer foods	2
21. Comprehensive study of population dynamics—measure of gains and losses in relation to range conditions, qualitative nutrition, competition	2
22. Studies of blood chemistry	2

This tabulation would seem to verify that, at least in the example chosen, most research effort supported by Pittman-Robertson funds is directed toward problems relating immediately to management. Admittedly, the summaries published in the Quarterly may not completely represent the work of the various research crews, in that quantitative data such as areas surveyed, animals checked through stations, etc., are emphasized to the exclusion of such qualitative observation as habits and behavior of the deer, or gradual changes in range vegetation. Nevertheless, we feel that the trend toward short-term, management-oriented studies is clearly indicated.

What then of the studies sponsored by teaching and research institutions? Do they complement the research of the administrative agencies by filling in the fundamental work on population dynamics and long-term ecologic relationships? In the opinion of this Committee they do so only in part. Although we have no source of statistics readily available for comparison with P-R reports, it is our collective feeling that much of the research on both fish and game conducted at universities and

research stations is scarcely more "basic" than that carried on in the state departments. By this we mean merely that the short-term project, with prospects of a quick thesis or journal paper, is dominant over the tedious, meticulous long-term study which in the end might yield much more of fundamental value to the profession. To this generalization there are, of course, some notable exceptions. Thus in the work of Errington on Iowa muskrats, of Cowan and his students on wilderness game, of Hazzard and coworkers on inland fisheries, and of the waterfowl crew at Delta, Manitoba, we see the frontiers of knowledge being substantially advanced not merely by bigger and better research appropriations but by skillful, persistent work directed toward comprehensive knowledge of ecologic principles. But on the whole, a cross section of contributions from university groups would not differ appreciably from that of government agencies. This is indicated by the distribution of awards made annually by The Wildlife Society for outstanding contributions to the literature of the profession. Since 1940, seven of the selected publications have come from workers in the administrative bureaus to only five from universities and research institutions.

As a profession, therefore, it seems that we are all bending our resources for original investigation in more or less the same direction. Very few of either the administrative or the academic groups are really attacking fundamental problems on a long-term basis. The collective output of present research programs is extremely useful, but it is somewhat overbalanced in favor of short, and quick, projects allied usually to current problems of management.

The commonest pattern of a wildlife research project is that a graduate student or a newly employed P-R biologist is assigned to study "The life history and ecology of such-and-such a species in such-and-such a locality." The boy works diligently for two or three years and if he is good, comes up with a report that serves as a thesis and/or journal paper, and then he moves on to some new assignment. His problem normally is abandoned in favor of some more pressing undertaking. Thousands of such projects add local detail to our knowledge of wildlife but very few reach the stage of adding a new principle. For example, there are countless reports presenting data on the quantitative food habits of game birds and mammals and virtually none on why some foods sustain large populations and others do not. In nearly every part of the country we know what per cent of the quail or pheasant nests are broken up by predators but in literally none do we know the role of year to year variations in weather as they affect nesting success. The literature is replete with accounts of deer eating up their ranges, but one must search long for specific data on the tedious process of rehabilitating an overbrowsed flora.

If we are slighting the long-term, the difficult, the exacting aspects of wildlife investigations, who should undertake them? Who should pay for them?

In the opinion of this Committee the whole profession has a stake in this problem and hence should assist in solving it. Leaving the "basic" research solely up to the academic institutions is not working in practice, however right

it may seem in theory. Two reasons may be: (1) The turnover of active research workers (the students) is very rapid and staff members normally are too busy with teaching and other academic duties to apply themselves diligently to routine research tasks; and (2) universities rarely have the funds to hold top-flight men on pure research assignments over long periods. These difficulties could be overcome in part by using series of graduate students to continue certain selected studies under the tutelage of staff members who presumably could supply the necessary continuity of policy and "know-how" of interpreting results. Or, if administrative agencies who hold the purse strings could support in university stations some experienced and proven men on full research assignments, results might be further hastened. The Fish and Wildlife Service actually does follow this policy as designated Research Units, although the Unit leaders are rather loaded down with administrative duties.

In the case of research conducted directly by the administrative agencies, without university affiliations, we would suggest the maintenance of at least a small number of established and productive investigators on long-term investigations designed to understand animal populations and ecologic processes rather then merely to solve today's crop of management problems.

As regards P-R research, it was pointed out in the 1952 report of this Committee that restrictions in the Federal Aid Policy Manual discourage long-term studies. Yet some states are conducting excellent research on P-R projects, which after all are easily renewable if they are getting good results. Even if P-R funds are not always available, the states could well afford to support small but high-quality investigational programs of their own.

Inadequacy of research programs sponsored by administrative wildlife agencies stems only in part from approaching problems in a superficial way. Perhaps even more fundamental is the failure to assign competent men to investigational work and failure to pay them enough to keep them there. Too often it is assumed that any man on the civil service list is good enough for research work, and the partial or complete failure of many studies has stemmed from inadequacies in personnel. Even short-term studies can sometimes pay handsome dividends if well staffed.

If even 10 per cent of the research effort of state, federal and university groups were consciously diverted from small undertakings and used to attack basic ecologic problems, we could greatly accelerate the construction of a skeleton of principles which would lend form and significance to the many short-term studies now underway. In the long run it is the principles rather than the details that will form a sound foundation for management.

In offering the above suggestions, this Committee does not mean to minimize the tremendous strides that have been made in the field of wildlife research since 1930. The establishment of Cooperative Research Units at many universities and the employment of wildlife teachers at others, the development of investigational programs in the Fish and Wildlife Service, and with the stimulus of Pittman-Robertson support in nearly all the states and territories, and more recently the development of

various privately financed centers of investigation, have permitted the wildlife profession in North America to assume a position of work leadership in ecologic investigations. Which, however, is no justification for complacency in the *status quo*. The self-appraisal here offered is intended to help us retain that leadership.

Respectfully submitted,
CLARENCE COTTAM
THOMAS R. EVANS
HARLOW MILLS
M. O. STEEN
S. C. WHITLOCK
A. STARKER LEOPOLD,
Chairman

REPORT OF THE WETLAND MANAGEMENT COMMITTEE

PREAMBLE

Wetlands are lands which may be submerged or seasonally flooded and which usually have their water tables close to or at the surface. Such lands of the North American continent contribute to human living standards and to the American way of life. Their retention, development, and maintenance are essential to the continued existence of migratory waterfowl, non-migratory wildfowl, many fur bearers, and valuable fauna and flora characteristic of this environment. We, the members of the Wildlife Society, present this basic policy designed to prevent waste and depletion of this valuable resource.

PURPOSE OF WETLAND MANAGEMENT POLICY

The purpose of the Policy for Wetland Management is to define the position of the Wildlife Society and to lay the foundation for a specific program of action that can be worked out in conjunction with other professional societies, governmental agencies, and private interests.

RECOGNITION OF NEED

A scientifically sound wetland management policy must recognize the need for retaining, restoring, and developing wetland resources to provide: (1) sustained and increased production of fish and wetlands wildlife; (2) recreational, esthetic, economic, and ecological benefits; (3) preservation of the soil and of surface and ground water resources; and (4) control of irrigation, drainage, and pollution where such practices are not consistent with a sound national program of natural resource conservation.

PRIVATE OWNERSHIP

The inherent right of private landowners must carry with it the obligation, moral if not at present legal, to care for the property in a manner that will ensure its continued use with the production of benefits, both economic and recreational, for future generations. Failure of private owners to provide wise management of soil, water and wildlife resources will lead inevitably to increased governmental supervision and control as productivity of mismanaged lands decreases while increased demands are made upon them by growing populations.

Private ownership and development of wetlands dedicated to the propaga-

tion and preservation of waterfowl and other wild crops of wetlands is to be commended. However, often the landowner cannot afford to pay for the development of such lands, since they may yield a return of greater public than private benefit.

Consideration should be given to compensation to private landowners who manage their wetlands so that wildlife is preserved and the public benefited. State and federal agencies together with private interests should encourage, plan, and participate in the development of wetlands for wildlife.

PUBLIC OWNERSHIP

Public ownership of many larger wetland areas is desirable to assure their preservation.

All public wetlands, both federal and state, should be developed and managed for the greatest production of waterfowl and other kinds of wildlife consistent with primary purposes. The individual states should accept and welcome the responsibility of proper development and management of wildlands, and especially wetlands.

CONTINENTAL PATTERN OF WETLAND MANAGEMENT

Every effort should be made to preserve the present continental pattern of wetlands valuable to wildlife because loss of suitable areas in one part will prove harmful to the whole. Extensive breeding areas for waterfowl in the north will be of little avail if feeding and resting areas along migration routes or wintering areas are lost.

In addition to retaining all the wetlands of wildlife value that we now have, we should try to fill in essential parts of the pattern that have been lost.

PUBLIC AID IN MANAGEMENT OF PRIVATELY-OWNED WETLANDS

Granting of subsidies, both in the form of money and public services, to aid and encourage the drainage of wetlands should be stopped where such drainage destroys good wildlife areas and results in a loss to the general public. We do firmly believe that drainage which is detrimental to any national resource should not be assisted or subsidized by a governmental agency. On the other hand, where lands are best used for wildlife conservation, both state and federal agencies should give technical assistance, encouragement and material aid to the landowner who is managing his land for the benefit of this national resource.

IMPROVED USE OF AGRICULTURAL LANDS

Present agricultural trends are toward better use of good farm lands and more intensive production of food crops. Emphasis by agricultural agencies should be placed on the better management of lands now in cultivation rather than upon creation of poor or fair farm land from excellent wildlife habitat. With improved farm management, the production of our better lands can be increased and the drainage of many marginal lands should not be necessary.

EDUCATION

Printed information and visual aids should be prepared on the value of wetland areas, economic and recreational, for all age levels. The value of proper management of wetlands should

be stressed. All organizations—federal, state, and private—having an interest in preserving and fostering our wetland resources should accept the challenge.

Educational institutions, public and private, have an urgent responsibility for teaching the values and methods of management of our renewable resources, including wetlands. All agencies and organizations directly concerned with wetland management should accept the responsibility for supplying schools with material suitable for class use.

RESEARCH

Factual information concerning problems of wetland conservation, restoration and management is needed. Methods proven of value by research should be applied promptly to maintain the resource while permitting maximum harvest.

Private owners of wetlands should be encouraged to cooperate in the testing of developmental and management ideas for which public funds are not available.

INVENTORY OF WETLAND RESOURCES

An inventory to define the present extent, condition, use and potential productivity of North American wetlands and to judge the effects of ecological trends, agricultural activities, flood control, navigation, hydro-electric power, industrial development, public health, pollution, and other social factors upon their present and future status is necessary. This inventory should serve as a guide for the preservation, acquisition, utilization, and management of wetlands of value to wildlife.

Respectfully submitted,

W. P. BALDWIN
E. B. CHAMBERLAIN, JR.
J. E. CHATTIN
J. W. KIMBALL
W. H. MARSHALL
L. S. ST. AMANT
HAYDEN W. OLDS, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

The following resolutions were adopted by The Wildlife Society at the annual business meeting, March 9, 1953.

WHEREAS: The campgrounds and recreational facilities of the National Forests were used by more than 30 million people this past year and the maintenance and development of recreational facilities and wildlife habitat are not being properly accomplished because of inadequate means of financing the work, now therefore,

BE IT RESOLVED: That The Wildlife Society urges the Congress of the United States to enact into law H. R. 1972, known as the Baker Bill to earmark a portion of National Forest receipts for the above development and maintenance work.

BE IT HEREBY RESOLVED: That The Wildlife Society urges the Congress of the United States to enact into law S. 71, known as the Robertson Bill, to require observance of state hunting and fishing regulations on all federally controlled lands.

WHEREAS, the present mining laws, passed by Congress in 1872, fail to recognize all public values and interests

in the public lands of the United States, and

WHEREAS, values, other than minerals, such as grassland and timber habitat for game, watershed protection, and recreation on our public lands have now become of importance and in some instances dominate the mineral values, now therefore,

BE IT RESOLVED: That The Wildlife Society urges the revision of the current mining claim laws so that the national, local, and public interests are fully recognized.

BE IT FURTHER RESOLVED: That copies of this resolution be sent to the Chairman of the House and Senate Interior and Insular Affairs Committees.

WHEREAS, the Wildlife Management Institute has furnished both financial aid and technical advice to workers throughout the United States and Canada, and has always attempted to raise the level of the wildlife management profession through their various media, now, therefore,

BE IT RESOLVED: That The Wildlife Society commend the Wildlife Management Institute for their many services rendered to the wildlife management profession.

BE IT RESOLVED: That The Wildlife Society extend to the Wildlife Management Institute, to members of the Program Committee of the 18th North American Wildlife Conference and to the Hotel Statler of Washington, D. C., sincere appreciation for facilities and courtesies which permitted the successful meeting of The Wildlife Society at the 18th North American Wildlife Conference.

KENNETH E. HUNGERFORD
FRED W. JOHNSON
H. R. NEWCOMB
BRUCE S. WRIGHT
ALBERT E. HYDER, *Chairman*

OBITUARIES

DONALD ROLAND BEMONT

1929–1951

Donald Roland Bemont, a member of The Wildlife Society, was born at Ste. Anne de Bellevue, Quebec, Canada, on May 9, 1929. As a youngster living in Ithaca, New York, his interest in birds was fostered by associations at Cornell University, where, later, he studied with a major in wildlife management. In the summer of 1950 he completed a very creditable limnological study in Quebec. On March 29, 1951, during the spring vacation of his senior year, he was accidentally knocked out of a tree on which he was working, and was instantly killed. Students of his caliber are few, and his tragic death was a loss to the wildlife profession.—OLIVER H. HEWITT

J. LEE DEEN

1896–1951

A charter member of the Wildlife Society, Dr. J. Lee Deen succumbed to a sudden illness April 24, 1951. He was born in Minnesota, November 15, 1896. He attended St. Olaf College and after serving in the Army during World War I, continued his education at the University of Minnesota receiving the B.S. degree in forestry with distinction, in 1927. He then entered the Yale graduate school, receiving the M.S. degree in 1929, and the Ph.D. degree in 1931. Upon finishing his graduate work, Dr. Deen was appointed instructor in silviculture and served in that capacity at Yale for two years.

In 1933 he was appointed on the staff of the Forestry Department of The Pennsylvania State College. At Penn State he soon earned the reputation of being an excellent teacher and an ardent and successful research worker. His forestry interests covered a broad field including wildlife management. He, along with a few other faculty members, was instrumental in establishing a Cooperative Wildlife Research Unit at The Pennsylvania State College. As part of that wildlife research program he contributed time and guidance to a fundamental deer—forest relationship study that was continued for a number of years after he left Pennsylvania. A number of important research papers have since been published from the research projects he initiated. Lee Deen was always cognizant of the human angles to forestry and wildlife management. Himself a sportsman, he was well aware of forest use by the near-million Pennsylvanian hunters. For years his main hobby was raising and handling beagle hounds for field hunting. The college woodlots and the valleys surrounding State College often resounded to the musical voices of his beagles.

Lee Deen's reputation as a teacher, student advisor, research worker, and genial host soon brought him many offers to leave Penn State. In 1938 Colorado A & M College convinced him that he should become their Dean of the School of Forestry and Range Management.

His career at Colorado A & M is well known. He built a strong School of Forestry and Range Management. He was instrumental in establishing both Cooperative Fishery and Wildlife Research Units at the College. He was a recognized leader on the campus, serving for a time after World War II as Dean of the College in addition to his forestry deanship.

Dr. Deen has a substantial bibliography, articles having been published in many scientific and professional journals. He was the author of two books, *A Swedish-English Vocabulary for Foresters*, and *Silvicultural Characteristics of American Trees*.

J. Lee Deen, although still a relatively young man when he died, accomplished much and his contributions to forestry education will be long remembered. The forestry and wildlife professions have lost a stalwart friend.

He is survived by his wife, Ruth, who resides at Fort Collins, Colorado. His ashes were interred in the mountain at Pingree Park, the location of the college forestry camp, an area he dearly loved.—LOGAN J. BENNETT

HENRY C. HAHN, JR.

1914–1952

The sudden death of Henry Charles Hahn, Jr., from bulbar poliomyelitis, May 27, 1952, at Kerrville, Texas, takes from the wildlife management scene one of the most popular, industrious and able technical men in the Southwest.

Born at Brenham, Texas, April 30, 1914, Hahn attended Alamo Grammar School in Brenham, the Brenham High School, Blinn Memorial Junior College, and the Texas Agricultural and Mechanical College at College Station, Texas.

Hahn was one of the charter members, as it were, of the group of students associated with

the early days of the Texas Cooperative Wildlife Research Unit, and participated in the first major field studies of the Unit in Walker County, Texas (for picture of Hahn and associates see "Land Wildlife Resources of the South," Mon. 4, Inst. for Res. Social Sciences, Univ. N. C., 1949, p. 57).

Developing an early interest in wildlife, Hahn paid part of his way during his school days in Brenham by conducting a fish-bait business in partnership with his life-long friend, Valgene W. Lehmann, now (1953) Game Manager of the King Ranch in south Texas.

Following his graduation from the Texas Agricultural and Mechanical College, with the degree of Bachelor of Science in Biology, in June, 1939, "Hank" immediately went to work for the Texas Game, Fish and Oyster Commission as Biologist, continuing in this position, with assignments of steadily increasing responsibility, until his death. His first assignment was at San Angelo, Texas, where he maintained his headquarters from December 1, 1940, until August 30, 1943, when he was transferred to the Edwards Plateau, in many ways the most important big game area in Texas.

He was married to Sarah Sutton of Montgomery, Texas, February 10, 1940.

Hahn was of strong and stalwart character. Honesty and kindness and thoughtfulness of others were markedly characteristic of Henry. But he was not in any sense a compromiser. He faced up to the problems of wildlife management with firmness. He did not equivocate on the obvious need for a greater harvest of deer in order to reduce the overpopulation of parts of the Edwards Plateau, although his stand was at first decidedly unpopular with a majority of sportsmen. As he lived and worked among them, Henry became increasingly well-liked by both sportsmen and ranchmen, and his considered judgments were more and more accepted.

While Henry was clear of mind and accurate of judgment, his method of getting ahead was less by brilliancy than by unremitting and conscientious industry. Ever and always cheerful and pleasant, Henry made an ideal camp companion. He always brought into the camp something different and good to eat, so we had more in the larder when he left than when he arrived! No wonder we were always delighted to have him join us, or to join him, in the field.

As his bibliography shows, Hank's chief interest was in big game, especially deer and wild turkey. The steady improvement in the administration of these important resources in Texas is in no small measure due to his painstaking labors.

Hahn took the lead in developing improved census methods for deer in the Edwards Plateau, where, under the Texas shooting preserve system, big game is of unusual interest and value to the ranchman as well as to the state.

He also played an important part in determining and emphasizing the economic value of big game in central Texas, and in making contributions to knowledge of the life habits, life equations, movements, irruptions and of others of the most pressing deer problems in the region. At the time of his death, Hahn was probably better informed from first hand contact on the white-tailed deer in Texas than any other man. He had also worked both intensively and extensively on the wild turkey.

Hahn was a member of the Kerr County, Texas, Wildlife Association, the Texas Academy of Sciences, the American Society of Mammalogists, and the Wildlife Society.

He is survived by his wife, his father and mother (Mr. and Mrs. H. C. Hahn of Brenham, Texas), a brother, Robert, and a sister, Gertrude.

A partial bibliography of his writings follows:

White-tailed deer in the Edwards Plateau. Tex. Game, Fish and Oyster Comm., (Federal Aid Project 1-R), pp. 1–52, illus., May, 1945.

A method of censusing deer and its application in the Edwards Plateau of Texas. Tex. Game, Fish and Oyster Comm., (final report, Federal Aid Project 25-R), pp. 1–24, illus., Feb., 1949, proc.

Economic value of game in the Edwards Plateau region of Texas. Tex. Game, Fish and Oyster Comm., Federal Aid Report Ser., no. 8, pp. 1–50, illus., May, 1951.

Bobwhite management. The Southern Sportsman, 5(2): 3 September, 1940.

Deer in the Hill Country. Tex. Game and Fish, 1(5): 7, 15 April, 1943.

A neglected asset. Tex. Game and Fish, **2**(12): 12–13 November, 1944.

A typical deer problem. (In co-authorship with Daniel W. Lay), Tex. Game and Fish, **3**(4): 12 March, 1945.

Mobility of Hill Country deer. Tex. Game and Fish, **3**(8): 17 July, 1945.

Cedar important to wildlife. Tex. Game and Fish, **3**(12): 27–28, November, 1945.

They die young. Tex. Game and Fish, **5**(11): 25–26, October, 1947.

Die-offs among the white-tailed deer in the Edwards Plateau of Texas. (In co-authorship with W. P. Taylor), Jour. Wildl. Mgt. **11**(4): 317–323, October, 1947.

Deer movements in the Edwards Plateau. (In co-authorship with W. P. Taylor), Tex. Game and Fish, **8**(12): 4–9, 31, November, 1950.

Unpublished manuscripts:

The white-tailed deer in Texas. Texas Game and Fish Commission (a revision and expansion of the 1945 bulletin which covered the Edwards Plateau only).

The Rio Grande wild turkey in the Edwards Plateau. (In co-authorship with W. P. Taylor, Harold L. Blakey, and E. A. Walker), Texas Game and Fish Commission.

—W. C. GLAZENER and WALTER P. TAYLOR

REVIEWS

Bobwhite Throughout the Year. 16 mm. colored motion picture produced by Charles W. Schwartz, with technical assistance by Jack Stanford, script by Werner Nagel, and narration by Bill Gamble. 50 mins. running time. Missouri Conservation Commission, Jefferson City, Missouri.

This motion picture, which, it will be noted elsewhere in this issue, was given special mention by the Society's Committee on Awards for Publications in the field of terrestrial wildlife ecology, has attracted tremendous favorable attention for its educational value. It was prepared for general audiences, and will certainly do inestimable good in teaching ecology and wildlife management to the Missouri public for which it was produced. I am told that the Commission has 17 prints of the film which have been in constant use since the day they were received and are booked solid for many months ahead. A number of other agencies have purchased from the Commission prints of the film at the cost of duplication ($370) to make it more widely available. No more need be said about the favor with which the public has received it.

The complete life history of the bobwhite is shown so effectively, with all major ecological requirements and mortality factors so effectively portrayed that the technical wildlife student will find the film an invaluable supplement to his studies. The Missouri Conservation Commission is to be congratulated upon having produced a superlative teaching film, which with its scientific accuracy, its excellent portrayal of wildlife management measures, and the beautiful scenes of hunting with bird dogs will have the widest possible audience appeal.—GUSTAV A. SWANSON.

A Survey of California Deer Herds, Their Ranges and Management Problems. By William M. Longhurst, A. Starker Leopold and Raymond F. Dasmann. Calif. Dept. of Fish and Game, San Francisco. 1952. Game Bull. No. 6. 136 pp. illus.

All persons interested in deer management problems—how they arose, how they can best be solved and what will happen to deer herds and ranges if proper solutions are not achieved —should read this fine bulletin.

It is a review and evaluation of the information acquired by the authors after an extensive survey of California's deer herds and ranges. The state was sub-divided into 111 natural management units, and the status of deer and major problems of management determined for each unit. The authors describe the history of the deer population and its past management, leading up to the present situation and problems. They describe how the range looks, why its appearance may mean the

range is fully stocked with deer and why the deer population on a management unit should be held at a level compatible with the food-producing capacity of that portion of the range that is occupied during the critical period of the year.

With this basic background the authors explain the large gains and losses in population experienced each year in deer herds. They explain why deer numbers are never static and show how the increases in a deer population are consistently opposed by decimating factors that counterbalance the upward trend. They present the reasons why these counterbalancing factors have now become so strong as to prevent any general increase in the deer population in most of the management sub-units.

Throughout, the reader readily understands why the "era of deer restoration" is over. Regulations and management tools appropriate to the past should be re-evaluated and discarded or supplanted by techniques designed to meet present needs, which are: to harvest a maximum annual crop of deer from existing breeding populations; and, to preserve and improve the ranges with a view to supporting the largest possible breeding population in future years. If management follows these two basic precepts, the waste of deer to starvation and disease, the destruction of ranges by over-use, and the agricultural damage caused by hungry deer will all be reduced. The year to year productivity of breeding deer populations and the yield of deer to California hunters will both be materially increased.

"Specifically, a breeding population of at least 1,126,000 deer in the state is producing a net annual crop of perhaps 250,000 animals. Of these, hunters are bagging about 75,000 bucks. Most of the rest are lost to starvation and disease, but only *after* they have damaged the range and in some cases also caused damage to crops. To prevent both the waste of deer and the damage, hunting regulations should be liberalized to permit a harvest of two to three times the present kill. This will necessitate harvesting some does as well as more bucks, under a program of careful, *local* regulation to achieve optimum distribution of the kill. A plan of subdividing the State into logical units and subunits for administering such local regulation is presented in this report."

This bulletin offers all who are interested in deer a fresh, constructive understanding of deer management and of range problems associated with populations of deer. Throughout, it is well organized and lucidly written.—C. W. SEVERINGHAUS.

Fundamentals of Limnology, by Franz Ruttner, translated by D. G. Frey and F. E. J. Fry. Univ. Toronto Press, xi – 242 pp. $6.50. 1953.

In making a revised edition of Ruttner's "Grundriss der Limnologie" available in translation, Frey and Fry have provided readers who prefer their books in English, with by far the best and most up-to-date introduction to limnology now existing. The author is well-known for his extensive researches on the lakes of Austria and of Indonesia; there are few aspects of limnology that he has not touched and none that he has touched that he has not ornamented. A lifetime of experience has gone into the volume; every student of the biology of inland waters will find desire to utilize that experience.

The book is a fairly conservative treatment of fundamentals, primarily for the beginner, but the present reviewer found a number of things new to him in its pages. Practically all the important phases of modern limnological research are moreover indicated, if only by citation of an advanced paper that is worth reading. The bibliography is admirably representative and international.

The book is divided into two parts, one dealing with the physical properties of water, and the physics and chemistry of lakes, the other with biotic communities. Particular attention is given to the plankton, but some space is devoted to the other major types of inland water community.

The discussion of Findenegg's work on plankton periodicity, the account of iron and of methane bacteria, and of the neuston, which are likely to be unfamiliar to many American limnologists, are specially noteworthy. In a few cases other workers would have adopted a different emphasis, but only the advanced student is likely to notice this and he is certain

to prefer to have Ruttner's particular views available in Ruttner's book.

Exceedingly few errors appear to have crept into the text; the density of "protoplasm" given on page 95, namely 1.05, is much too high; Luntz' figure of 1.025 for a rotifer, given on a later page, is a far more reasonable figure. The point would be hardly worth making had not the higher value based primarily on benthic marine animals become widely disseminated in the European literature; this higher value corresponds, of course, to an excess density, over that of the medium, just twice that exhibited by Luntz' rotifer. One would have preferred Aberg and Rodhe's useful term, for what is often miscalled a eutrophic oxygen curve, to have been spelt in English—*clinograde* rather than *klinograde*. The present reviewer, perhaps idiosyncratically, since he was born and lived on one, also finds "flatmoor" a clumsy translation of *Flachmoor*, when the English word "fen" already exists in the language. These are admittedly very minor points, to be considered in preparing a second English edition, which is certain to be required.

The book is enthusiastically recommended to everyone concerned directly or indirectly with inland waters. Biologists, fisheries investigators, sanitary and waterworks engineers, and many geologists will find it an indispensible part of their libraries. It is unfortunate that the publishers have felt the need to set the price at a figure that will undeservedly limit the circulation of so useful a book.—G. E. HUTCHINSON

RECENT PUBLICATIONS

Annual Report for the Year 1951 and Short Papers. Institute of Freshwater Research, Drottningholm, Sweden. Report No. 33, Fishery Board of Sweden. 232 pp. 1952.

Ten research reports of general interest to fishery biologists and limnologists.

Ecology and Management of Fisher and Marten in Ontario. By Antoon de Vos. Ontario Department of Lands and Forests. 1952. 90 pp.

Includes sections on biology of each species, ecological relationships, populations, management, special studies in the Chapleau Forest District which was studied most intensively, and future work suggested.—G. A. SWANSON.

Wildlife Management. By Durward L. Allen. Boy Scouts of America, New York 16. 96 pp. 25 cents.

This new booklet is one of the merit badge series of the Boy Scouts, and certainly one of their best. Packed with useful information, presented in most concise form, still it is readable and so attractively illustrated that it is certainly destined to do inestimable good in educating the coming generation in the principles and problems of wildlife management. "Wildlife" is broadly interpreted to include the fisheries as well as terrestrial forms.—G. A. SWANSON.

Investigations of Woodcock, Snipe, and Rails in 1952. Special Scientific Report: Wildlife No. 18. U. S. Department of Interior, Fish and Wildlife Service, and Canada Department of Resources and Development, Canadian Wildlife Service. 55 pp. (Processed.)

The American Museum of Natural History, New York 24, and the R/W Maintenance Corporation, Buffalo 9, N. Y., announce the release of a 23-minute colored sound film entitled "Rightofway Brush Control, A Scientific Program of Vegetation Management." This film describes and demonstrates the botanical system of brush control developed by Dr. Frank E. Egler of the Museum. This long-term low-cost system involves an initial "conversion," now done by selective basal spraying. Subsequent "maintenance" is effected largely through leaving those plants that most efficiently resist tree reinvasion. In addition to landscape, fire hazard, and other conservation values that are emphasized, this film is of particular interest to those in wildlife management, since the lowest cost program for the utility corporations is also optimum for wildlife food and cover. Copies of the film may

be obtained on loan from the R/W Maintenance Corporation, for commercial showings. For other uses, a copy can be obtained from the American Museum of Natural History, New York 24.

Prairie Chickens of Kansas. By Maurice F. Baker. State Biological Survey, University of Kansas, Lawrence. Misc. Pub. No. 5, 68 pp. illus. March, 1953.

A concise but satisfying report dealing chiefly with the greater prairie chicken on a three-square-mile study area on optimum range in Kansas. Management discussions and recommendations occupy five pages.

Papers on Game Research, Nos. 8 and 9, Finnish Game Foundation, Game Research Institute, Helsinki, P. Rautatiek. 13, Finland. 1952.

No. 8 contains the proceedings of the conference of game biologists of the Northern Countries (Denmark, Norway, Sweden, Finland) held May 11-19, 1952 in Helsinki. The program included some 20 papers—12 in English, the rest with English summaries. The conference organized a uniform system of game inquiries throughout the Northern Countries, with an exchange of game biologists.

No. 9 is "On the reflection of short-term fluctuations in numbers in the reproduction of tetraonids," by Lauri Siivonen.

Surveys of elk and other wildlife in Riding Mountain National Park, Manitoba, 1950–1951, and 1952. By D. G. Colls. Canadian Wildlife Service, Department of Resources and Development, Ottawa. Wildl. Mgt. Bull. Series 1, No. 6. 25 pp. illus. Processed. December, 1952.

The economic status of the herring gulls of the Grand Manan Archipelago, New Brunswick, 1949. By D. H. Pimlott. Canadian Wildlife Service, Department of Resources and Development, Ottawa. Wildl. Mgt. Bull. Series 2, No. 5. 76 pp. illus. Processed. June, 1952.

Severn Wildfowl Trust. Fifth Annual Report, 1951–52. Country Life Limited, London. 191 pp. illus. 10 s.

Similar in style and attractiveness to its predecessors, this publication describes the progress of the Severn Wildfowl Trust, and includes many short articles of interest to waterfowl biologists. It contains Part Three of the series on the Swans, Geese and Ducks of the British Isles, with three excellent plates in color by Peter Scott.

Guide to the Fishes of Colorado. By William C. Beckman. Colo. Game and Fish Dept. 110 pp. $1.00. (not dated but appeared in 1952).

This well-prepared guide should prove valuable to field men in the Rocky Mountain region. It has many features which should be incorporated into all field guides. The key to families is illustrated to show body form. A brief diagnostic description of each family is given, followed by keys to genera and species. Each species is illustrated by a line drawing with identification features labelled. A short technical description including body proportions, scale and ray counts, a description of color in life, very brief life history notes, and a statement of status in Colorado are given for each species. The keys are further augmented by a glossary and an illustrated section demonstrating methods of making various measurements and counts so that even persons with little training in the use of keys should have little difficulty in identifying most Colorado fishes. Included in the Guide are 89 species and subspecies in 16 families.—K. D. CARLANDER.

VI Bulletin of The International Committee for Bird Preservation. 248 pp. 1952. Available from Richard H. Pough, Secretary and Treasurer, United States Section, American Museum of Natural History, New York. $1.75 plus 15 cents postage.

In English, French, German and Spanish, this bulletin contains principles and by-laws of the Committee; summaries of recent conferences of the Committee and various Sections; a description (5 pages in English) of the International Wildfowl Research Institute, to promote research on waterfowl in Europe; and concise statements of the situation regarding bird protection in 23 countries.

BRIEFER ARTICLES

FOOD HABITS OF THE FERAL HOUSE CAT IN EAST-CENTRAL TEXAS

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In the Post Oak Region of east-central Texas, sportsmen and many landowners believe the house cat to be one of the most important predators on the bobwhite, although evidence does not conclusively verify this belief. Data presented here give some indication of the food habits of this animal in this region. Feral house cats and those which are forced to secure their own food, are common throughout the agricultural area, which forms the main bobwhite range.

Thirty-three house cats were collected in Brazos, Robertson and neighboring counties between June 1950 and December 1951, 31 of which contained food in the stomach. All were shot along roadsides or in fields and woodlots with the exception of three that were taken in steel traps and three that were found dead on the road. Stomach contents are listed in Table 1.

Errington (Jour. Mamm. **17**(1): 64–65, 1936), in discussing the food habits of southern Wisconsin house cats, is of the opinion that the manner in which the cats are collected does not present a really true cross-section of food habits. Those cats that hunted along roadsides, in stubble and hayfields or those picked up dead on the highways were readily seen and collected, while "the elusive woodsdwellers, which are most likely to be feral and to have the best access to avian prey," are seldom taken. These observations may hold true, in part at least, for the Post Oak Region, although a larger number of song birds and quail frequent the roadsides and the more open fields and semi-brushy areas.

Of the 31 stomachs examined, two contained food that had apparently been fed to them by The owners. The cotton rat was taken more than any other single food item. This is probably because more cats were collected along roadsides and in brushy areas in and bordering pastures, where populations of *Sigmodon hispidus*, although low in the latter part of 1950 and 1951, were still surviving.

Only one of the cat stomachs contained remains of bobwhite quail. On October 15, 1951, a Negro tenant living on a portion of land that

TABLE 1.—QUALITATIVE ANALYSIS OF 31 STOMACHS OF FERAL HOUSE CATS COLLECTED IN THE CENTRAL POST OAK REGION

	Number	Frequency of Occurrence
Sigmodon hispidus (Cotton Rat)	15	13
Sylvilagus floridanus (Cottontail Rabbit)	4	4
Mus musculus (House Mouse)	4	4
Perognathus hispidus (Hispid Pocket Mouse)	3	3
Peromyscus sp. (White-footed Mouse)	2	2
Gallus domesticus (Domestic Chicken)	2	2
Colinus virginianus (Bobwhite Quail)	1	1
Agelaius phoeniceus (Red-winged Blackbird)	1	1
Opheodrys aestivus (Rough Green Snake)	1	1
Sceloporus undulatus (Fence Lizard)	1	1
Cnemidophorus sp. (Racerunner)	1	1
Leiolopisma laterale (Little Brown Skink)	2	2
Insects (Principally Grasshoppers and Black Crickets)	63	9
Grass	–	2
Bread	–	1

had been used as a study area, reported that his adult male cat had returned early that morning with a male bobwhite. These are the only instances in which the house cat was recorded as a predator on bobwhite.

In discussing house cat depredations with local quail hunters, the majority stated that it was their general policy to shoot cats found away from human habitation during hunting trips. A practice such as this helps serve as a control measure and reduces the number of feral and vagrant cats for at least a two-months period. The feral house cat may, when it becomes numerous in a local area, seriously reduce the number of quail in winter covey or nesting birds and young during the nesting season. Apparently, however, bobwhites in the Post Oak Region are preyed upon by the house cat only incidentally.

This paper is a contribution from the Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas. The work was part of a two-year ecological study of the bobwhite quail in the Post Oak Region of Texas. Cooperating were the Texas Cooperative Wildlife Unit, the Wildlife Management Institute, the Texas Game and Fish Commission and the U. S. Fish and Wildlife Service.

Accepted for publication August 24, 1952.

REPORT OF MINNESOTA BEAVER DIE-OFF, 1951–1952

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In early spring, 1952, reports were received from state game wardens in Grand Marais, Minnesota, that Indians were reporting dead beaver in Canada just north of the International Boundary. This was followed by reports from beaver trappers who stated that dead beaver were found under or in the ice near colonies they planned to trap during the approaching season in Minnesota. Due to the mild winter and fast run-off of surface waters, some trappers were of the opinion that beaver had starved to death or had been caught without sufficient water behind the dams. This was discounted when dead beaver reports began to show up all over the open trapping area and from colonies which still had a good water supply. Because of the widespread mortality, it was assumed that some disease was decimating the beaver population. During the fall of 1951, hundreds of muskrats had reportedly died of tularemia and several trappers in the Crane Lake - Buyck - Orr country of northern Minnesota contracted the disease. It was possible that beaver, also, had picked up the tularense organism, but there is no evidence that trappers suffered from tularemia during the spring of 1952.

Dead beaver reports were received from all counties open to trapping, with the exception of the prairie counties in the Red River Valley in northwestern Minnesota. Beaver undoubtedly died in Pine, Aitkin, and Crow Wing Counties, which lie just south of the 1952 open trapping area, but no reports were received since there was no occasion for trappers to be checking colonies. No dead beaver were reported from the open trapping area along the Mississippi River in southeastern Minnesota from Lake Pepin to the Iowa Border in 1952, but four were turned in for examination from this area in April, 1950. On April 28, 1950, two beaver were found dead in the Whitewater Refuge about twenty-five miles west of Winona on the Mississippi River. They were sent to the Mayo Foundation in Rochester, Minnesota, for examination. Dr. Luther Thompson of the Mayo Foundation isolated *P. tularense* from both animals.

Dead beaver totalling 407 were reported found during and after the open season of April, 1952. In addition, reports of "several" and "numerous" dead beaver were received in Grand Marais, Cook County, Jackfish Bay of Basswood Lake in Lake County, Ely and Hibbing in St. Louis County, International Falls in Koochiching County, Grand Rapids and Remer in Itasca County, and Bemidji in Beltrami County. Reports received by the

Kananen Fur Company in Grand Rapids were said to run into the hundreds. Some typical reports were as follows: Ed Dilley of Isabella found a total of 15 dead—3 in lodges, 2 dead on Huntingshack River, 2 dead on Gannon Creek, 3 dead on Moose River, 8 dead on Knox Creek, 2 dead in Township 60 North, Range 22 West, 15 dead near Winter Road Lake, and so on . . . . .

Many trappers reported colonies now "dead" which were active last fall. The beaver are gone but the food piles remain. The condition of most carcasses along with the fact that some were found frozen in the surface ice of rivers and fed on by wolves and fox, suggested that they had been dead all winter. It is believed that the largest part of the die-off occurred early in the winter, and that occasional animals continued to die all winter long. The disease was spotty. Some trappers had good luck, taking as many as 8 and 11 beaver from a single colony and not finding a single carcass. Others trapped as many as five colonies and only managed to get two or three beaver. Some colonies had been completely wiped out, others remained untouched. In some cases one or two beaver remained in a colony where several had died.

A four-day check was made in the Oyster Lake Country in Superior Refuge No. 9 with the assistance of Patrolmen R. Jacobsen and R. Thorpe. Eight beaver were found dead in the water, all badly decomposed. No doubt many more died, but bear sign was common on all beaver dams and several turkey vultures were working in the area so they undoubtedly cleaned up some carcasses. One fresh bear bed was found near the remains of one beaver. Both trapped and untrapped areas were checked in Unit No. 9 and dead beaver were found in each. Some beaver sign remained in the area examined so it appears that neither trappers nor disease eliminated the entire population. Carcasses and parts of carcasses were sent to Dr. Fenstermacher of the Animal Diagnosis Laboratory, University of Minnesota, who in turn sent cultures to Dr. Jellison of the U. S. Public Health Laboratories in Hamilton, Montana. Dr. Jellison was unable to obtain the tularense organism from any of the cultures. Lesions of the spleen of one carcass were indicative of tularemia, but in no case was the actual organism isolated.

It is believed that the number of beaver which died from the disease will equal or exceed the number actually taken by trappers. This, in spite of the fact that there have been annual trapping seasons on beaver since 1948 with two seasons in 1950, and a total harvest of 54,000 animals has been taken during that time.

In order to get more information on the extent of the epizootic, correspondence was initiated with the Wisconsin Department of Conservation and the Department of Lands and Forests, Province of Ontario. A reply from G. J. Knudsen of the Wisconsin Beaver Research Project stated that ten dead beaver had been found near Hayward. Field work and laboratory examination of carcasses gave results similar to those for the Minnesota examinations. Namely, that organs showed symptoms of tularemia lesions, but that the tularense organism could not be isolated. It was Mr. Knudsen's opinion that the animals had died during the winter.

A letter from Dr. A. de Vos, biologist with the Ontario Department of Lands and Forests, stated that tularemia had been observed among beaver during the past four years in Manitoba and Ontario with a severe outbreak occurring during the winters of 1949-50 and 1950-51 in the Patricia portion of the Sioux Lookout District of Ontario. The tularemia organism was isolated in the laboratory of the Ontario Research Foundation.

As early as 1800, a beaver die-off was recorded in northern Minnesota. John Tanner, a white captive raised by Indians, mentions in his book (The narrative of the captivity and adventures of John Tanner during thirty years residence among the Indians in the interior of North America. G. & C. & H. Carvill, New York. 1830.) that ". . . . . some kind of distemper was prevailing among these animals, which destroyed them in vast numbers. . . . . Many of them which I opened, were red and bloody about the heart. Those in large rivers and running water suffered less; almost all of those that lived in ponds and stagnant water, died. Since that year the beaver have never been so plentiful in the country of Red River and Hudson's Bay as they used formerly to be."

Accepted for publication September 8, 1952

YIELDS OF SEEDS AND MAST IN SECOND GROWTH HARDWOOD FOREST, SOUTHCENTRAL MISSOURI

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Wild turkeys eat acorns, particularly those of post oak and blackjack oak. Dalke, Clark, and Korschgen (1942) found that acorns comprise the largest single item in the turkeys' diet during the fall and early winter. The abundance or scarcity of the acorn crop in any locality has a profound influence on the movements of turkey flocks. Wild turkeys do a considerable amount of scratching for acorns as well as for other plant foods and the daily range usually includes acorn mast as long as it is available.

In the course of a field investigation on the ecology of the wild turkey, a portion of the work centered in and around Indian Trail State Forest, a wildlife refuge near Salem, Missouri.

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TABLE 1.—SUMMARY OF SEED AND MAST YIELD ON 452 MIL-ACRE PLOTS IN THE FALL OF 1938

Species	No. of Plots	Av. No. Seeds Per Mil-Acre	Av. Wgt. in Lbs. Per Acre	PERCENTAGE			
				Sound Seeds	Wormy Seeds	Undeveloped Seeds	Partly Eaten
Black Oak *Quercus velutina*	222	21.3	55.0	22.6	59.6	16.5	1.3
White Oak *Quercus alba*	95	6.5	21.0	1.4	71.8	26.4	0.4
Scarlet Oak *Quercus coccinea*	48	40.1	159.0	35.2	48.1	13.6	3.1
Red Oak *Quercus rubra borealis*	38	25.9	228.0	59.7	31.2	8.4	0.7
Wild Rose *Rosa* sp.	27	1.2	1.0	90.7	1.1	8.2	—
Post Oak *Quercus stellata*	22	8.3	5.0	1.9	38.8	58.5	0.8
Blackjack Oak *Quercus marilandica*	18	7.2	13.0	27.9	46.4	22.7	3.0
Lespedeza virginica	18	143.3	1.0	93.4	1.5	5.1	—
Coralberry *Symphoricarpos orbiculatus*	14	236.6	71.0	95.2	4.8	—	—
Hickory *Carya* sp.	5	0.3	3.0	20.0	20.0	40.0	20.0
Sumac *Rhus* spp.	5	331.9	8.0	94.9	2.5	2.6	—
Hazelnut *Corylus americana*	2	0.9	7.0	33.3	66.7	—	—
Flowering Dogwood *Cornus florida*	1	6.8	2.0	100.0	—	—	—
New Jersey Tea *Ceanothus americanus*	1	1.3	Trace	100.0	—	—	—

The timber in Indian Trail State Forest varies from dense sprout growth to scattered stands of mixed oak and hickory. There are approximately 20 trees per acre over 10 inches DBH, of which half of these are in the 10- and 12-inch diameter class (White, 1951). During the early phases of the turkey project, a CCC camp operated in Indian Trail State Forest. In an attempt to secure data on the yield of seeds and mast in the various cover types on the refuge, a crew of CCC enrollees were trained for the work. Four compass lines were run, each from one to two miles in length, cutting across all the cover types. In 1938, 452 plots of one mil-acre each were established at one-chain intervals along 5.6 miles of surveyed line, in general cutting across ridges and ravines. Each plot was marked at four corners. The 452 plots established in 1938 were also used in 1939, plus 42 more, on a total of 6.2 miles of line.

The collection of the mast and seeds was a considerable task, and with the abandonment of the CCC program in 1940, additional seed yield information on the scope of the initial effort had to be abandoned.

TABLE 2.—SUMMARY OF SEED AND MAST YIELD ON 494 MIL-ACRE PLOTS IN THE FALL OF 1939

Species	No. of Plots	Av. No. Seeds Per Mil-Acre	Av. Wgt. In Lbs. Per Acre	PERCENTAGE			
				Sound Seeds	Wormy Seeds	Undeveloped Seeds	Partly Eaten
White Oak *Quercus alba*	80	9.8	22.0	3.6	38.5	43.2	14.7
Post Oak *Quercus stellata*	62	13.7	9.0	6.2	50.3	38.9	4.6
Black Oak *Quercus velutina*	50	4.4	6.0	2.2	42.1	45.6	10.1
Blackjack Oak *Quercus marilandica*	2	1.6	2.0	18.2	45.4	36.4	0.0
Hickory *Carya* sp.	6	4.2	13.0	0.0	83.3	14.1	2.6
Lespedeza virginica	27	37.3	2.0	72.7	—	27.3	—
Rose *Rosa* sp.	15	4.8	4.0	88.7	0.4	8.3	2.6
Coralberry *Symphoricarpos orbiculatus*	7	245.7	4.0	36.0	—	64.0	—
Red Oak *Quercus rubra borealis*	2	14.5	36.0	0.0	44.4	33.4	22.2
Tick Trefoil *Desmodium* spp.	7	103.6	1.0	73.8	—	26.2	—
False Indigo *Amorpha fruticosa*	9	12.1	0.3	52.8	43.9	3.3	—
Hazelnut *Corylus americana*	1	0.3	1.0	100.0	—	—	—
Partridge Pea *Cassia chamaecrista*	1	37.8	2.0	100.0	—	—	—
Flowering Dogwood *Cornus florida*	1	0.6	0.4	100.0	—	—	—
Hawthorn *Crataegus* sp.	1	9.7	8.0	86.7	—	10.0	3.3
Hackberry *Celtis occidentalis*	1	53.1	18.0	95.7	—	4.3	0.0

The wide divergence of results during 1938 and 1939 illustrates how variable is the food supply for those animals dependent upon seed-producing plants.

The plots were visited about once a week during the time the acorns were being dispersed. The volume or weight of all seeds produced could not, of course, be an absolute measurement of the yield, since some seeds were probably consumed by birds and mammals in between collections.

In 1938, 22.8 per cent of the plots yielded no seeds or mast; in 1939, 44.9 per cent of the plots were bare of seeds. The yield of seeds in 1939 decreased by approximately 90 per cent from the 1938 figure.

The tables summarize the data for the years 1938 and 1939.

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Accepted for publication July 14, 1952.

ACORN PRODUCTION IN EAST TEXAS

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Annual fluctuations in the abundance of acorns are of importance to wildlife in many areas. This is particularly true in the hardwood districts of east Texas, where almost pure stands of somewhat stunted post oaks (*Quercus stellata*) comprise the characteristic forest vegetation.

Observations of acorn abundance in post oak forests during the summers of 1949, 1950 and 1951 were made in Robertson and, to a lesser extent, in Brazos counties, Texas. These were undertaken mainly to try out a possible method for quantitatively appraising the abundance of acorns from year to year prior to maturing of the crop. Incidental observations were made on the size characteristics of the trees as related to production. For the most part, the study was limited to the post oak, but a few observations were made on the blackjack oak (*Q. marilandica*).

Since acorns of the white oak group are borne on the twigs (that is the terminal subdivisions of the branches but including only the current year's growth), it is not possible to measure year to year production on the same twigs, and various obstacles prevented planned study of marked trees and branches, which probably would be desirable in a long-time study of acorn fluctuations (provided that the period is not so long as to permit significant tree growth).

The system adopted was thought to be suitable for widespread use by non-technical personnel, should it be desirable to secure state-wide information on the acorn crop. The method merely involved the counting of acorns occurring on the first 25 twigs encountered on each tree. In Texas, nearly all trees studied had readily accessible branches. In areas of taller oaks, some samples might have to be secured by pole pruner or otherwise.

Annual averages, tallied in Table 1, indicate (1) striking changes in nut production from one year to another, (2) moderate losses between early and late summer in 1950, (3) decreased production (by conspicuously smaller trees) on poor soils, (4) a probably non-significant correlation between acorn pro-

TABLE 1.—ACORN COUNTS IN THE POST OAK BELT OF EAST TEXAS

Date	Area & Site	Number of trees	Av. No. Acorns per 25 Twigs	Inches of Rain during Flowering Period
		Post Oak		
Aug. 18, 1949..	Seale Ranch, Robertson Co., sandy prairie border	20	0.85	3.08*
June 18, 1950..	Same area	35	25.49	2.37*
Aug. 25, 1950..	Same area	25	14.32	2.37*
Aug. 20, 1951..	Same area	35	1.06	3.32*
Aug. 24, 1950..	Fish Lake, Brazos Co., clay upland—eroded	30	7.93	0.00**
		Blackjack oak		
Aug. 25, 1950..	Seale Ranch, Robertson Co., sandy prairie border	6	3.80	Flowering period not studied.
Aug. 20, 1951..	Same area	5	17.40	"

* Measured at Wheelock, 2 miles distant.
** Measured at College Station, 1 mile distant.

duction and deficient rainfall during the March 20-30 period of pollen production, and (5) at least a fair value of the survey method attempted.

Observations on the relation of tree dimensions to acorn production also were made and are summarized in Table 2. As has been found previously (Baker, Theory and Practice of Silviculture, New York, 1934), large dominant trees were the main seed producers. In general, the taller the trees, the larger the trunk diameter and the more spreading the crown, the greater the fruit yield. Not only was the acorn production per twig greater on mature and

TABLE 2.—AVERAGE NUMBERS OF POST OAK ACORNS PER 25 TWIGS ACCORDING TO TREE CHARACTERISTICS, ROBERTSON COUNTY, TEXAS
(The figures in parentheses are the numbers of specimens seen)

Diameter at breast height	June 1950	Aug. 1950	Aug. 1951	Totals
6″–10″	2.0 (3)	4.0 (5)	0.8 (14)	1.7 (22)
11″–15″	25.6 (21)	13.5 (8)	1.1 (11)	16.4 (40)
16″–20″	26.5 (9)	24.4 (8)	0.6 (5)	18.9 (22)
21″–25″	54.5 (2)	8.3 (4)	2.2 (5)	13.9 (11)
Height				
21′–30′	4.3 (5)	21.3 (4)	0.9 (17)	4.7 (26)
31′–40′	24.6 (12)	13.0 (21)	0.1 (6)	14.6 (39)
41′–50′	32.3 (12)	—	2.0 (11)	17.8 (23)
51′–60′	26.5 (6)	—	0.0 (1)	22.7 (7)
Crown				
Narrow	14.5 (16)	4.0 (6)	0.7 (17)	6.9 (39)
Spreading	34.1 (19)	17.6 (19)	1.4 (18)	14.4 (56)
Totals	25.5 (35)	14.3 (25)	1.1 (35)	13.5 (95)

dominant trees, but the much increased number of twigs per large tree further increased their value in mast production. Acorns were absent from the small oaks under 6″ d.b.h. which were examined.

As noted by Cypert (mimeo. report of Southeastern Asso. Game and Fish Comm., 1951) in Kentucky, certain post oaks isolated in open pastures produced high yields even in poor years. One such tree on the Seale Ranch, produced up to 97 (average of four counts was 44) acorns per 25 twigs in August, 1949, when the regular study area production averaged 0.85 nuts per sample.

Accepted for publication October 6, 1952.

THE USE OF HAY CROPS IN SOUTHEASTERN WATERFOWL MANAGEMENT

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Although the Southeast is recognized as a principal wintering ground for a large part of the continent's waterfowl, its rapidly expanding population, industry, and agriculture are seriously limiting both the habitat and the once abundant supply of natural foods. A major problem confronting waterfowl managers in this region is the production of sufficient food to maintain the wintering concentrations. Where uplands suitable for agricultural use are adjacent to water areas, they can be made to produce a quantity of food for all species of geese and the field-feeding species of ducks. The use of farm row crops to produce highly nutritious food, coupled with fall plantings of small grains and other winter crops to furnish green browse, will usually make available the greatest quantities of preferred foods. Good land management or local economy may prescribe hay crops. Properly handled, these hay crops can contribute to waterfowl management.

Material for this paper was gathered from the various southeastern refuges of the United States Fish and Wildlife Service, notably the Wheeler, Tennessee, Santee, and Kentucky Woodlands Refuges, and also from state-managed refuges, public shooting areas, and from general observations on private farms and club-owned lands.

Hay crops can have both direct and indirect values to waterfowl management. Their place in crop rotations and soil conservation is a familiar one. They can be used on lands unsuited for row crops, and, when the demand for row crop acreages is low, can provide a means for holding land open and in a standby condition. Waterfowl use of small row-cropped fields is often limited, and hay crops on lands surrounding such small fields will increase waterfowl use of the smaller areas.

A more direct value of hay crops is in furnishing food for waterfowl, especially browse for geese. Ducks make only limited use of hay lands except under special circumstances. If hay fields are to be of browse value, they must be well located and of sufficient size to give the birds a feeling of safety. For best use they should be at least ten acres in area, although the size requirement will depend on both shape and location.

Crops which are commonly used for hay in the Southeast and are of browse value for waterfowl include alfalfa, crimson, white-Dutch and Ladino clovers, Aldous and Kentucky 31 fescue, redtop, and orchard grass. Oats, cowpeas, peanuts, and some of the millets and soy beans are used for hay and will produce some waterfowl food. The lespedezas, Sudan and Johnson grass are common hay crops but have only indirect value in waterfowl management.

In many respects alfalfa is one of the most valuable of these crops, furnishing highly preferred browse for geese, and used to some extent by ducks. For best waterfowl use it should receive a late mowing shortly before the first killing frost in order to remove rough and expose the tender, new growth. Here, care must be used, since mowing too late may damage the stand, and failure to mow late enough may reduce waterfowl use.

Crimson clover and oats, planted in mid-fall, are commonly used as hay crops in the Southeast. Both will furnish excellent goose browse, usually without damaging their hay value the following spring. To obtain good use by geese it is only necessary to gauge the time of planting properly. Very early plantings of these species, especially oats, may become too tough and rank for good browse before the birds arrive. Plantings made too late may be damaged by heavy browsing in the early stages or simply fail to carpet the ground thoroughly enough to attract geese during late fall.

Although primarily used in pastures, Ladino clover mixed with fescue or orchard grass is sometimes used for hay. Well liked by geese, it is only necessary to keep growth low by late mowing to obtain good use.

Kentucky 31 and Alta, tall meadow fescues, especially adapted to low or poorly drained soils and often used for sodding waterways, are primarily pasture grasses but are sometimes planted for hay. First year stands are especially well used. Older stands may require close mowing to keep growth succulent enough for best use. It has not been demonstrated that close mowing alone will keep older stands in a condition suitable for best waterfowl use.

In the more northerly parts of the southeastern region, both orchard grass and redtop are commonly planted for hay and grazing. These are often mixed with Ladino clover or other perennial grasses and legumes. The importance of orchard grass and redtop as goose browse has not been conclusively proved, but the mixed plantings are usually subject to waterfowl use ranging from fair to good. As with all other similar plantings, it is most important that growth be kept low and succulent.

Various summer annuals used for hay, including varieties of soy beans, cowpeas and brown top, German and pearl millet, mature seed that are well used by waterfowl. Hay cutting will, of course, prevent seed maturity but, where a share rental system is used, rental portions may be left uncut for waterfowl use. These crops are used especially well when planted in basins or on low fields subject to flooding. When planted on uplands it may be necessary to drag or cut down stalks to insure good use. Here, where public shooting grounds or private lands are concerned, care must be used not to infringe upon state or Federal anti-baiting regulations.

Peanut tops, mowed green, are sometimes used for hay. If mowing can be delayed until nuts are nearly mature, production is not seriously impaired. The nuts are excellent food for both ducks and geese, and the use of tops for hay will often make the nuts available without further treatment. In heavy soils, however, it may be necessary to plow nuts up for best waterfowl use.

Accepted for publication Aug. 13, 1952.

SNAPPING TURTLE CATCHES PHEASANT

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That a snapping turtle may capture a full-grown ring-necked pheasant was observed on June 26, 1952 on a farm in Berks County, Pennsylvania, by Charles H. Lloyd of the Soil Conservation Service. He was crossing a poorly-drained area on a farm that contained scattered patches of emergent aquatic plants and very small areas of shallow water when he heard a fluttering of wings. Upon investigation he observed a hen pheasant fluttering in a shallow pool of water with its head beneath the surface. He pulled the pheasant up into the air and discovered that a snapping turtle about one foot in diameter had fastened firmly on the pheasant's neck. The snapper had apparently grabbed the pheasant by the neck as it drank at the pool since it would be improbable that the turtle could reach the neck if the pheasant had merely been walking by. The pheasant died before it could be released.

Accepted for publication Aug. 27, 1952.

HIGH OCCURRENCE OF *TAENIA TAENIAFORMIS* IN THE MUSKRAT[1]

(*Ondatra z. zibethica*)

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During the course of an economic study of the muskrat in Virginia, rather high parasitism in the species was noted on Stroubles Creek, a small stream in Montgomery County. The parasites were identified as a strobilocercus form of *Taenia taeniaformis* which were firmly encysted in the liver of a number of animals. Identification was confirmed after several of these strobilocercus forms had been passed through a cat and the adult worms recovered.

This parasite is a cestode found in the small intestine of domestic cats, dogs, wildcats, and other closely related carnivores (Morgan and Hawkins, 1949: 219; Mönnig, 1947: 129; Nevell-Lemaire, 1936: 612; Dikmans, 1945: 230; Vogelsang, 1925: 395). The larval or bladder worm stage, usually known as *Cysticercus fasciolaris*, occurs in an encysted form in the liver of various rodents, including rats, mice, and muskrats. It has also been known to occur in the liver of wild rabbits. Neither the adult nor the larval stage appears to be of great economic importance. The larval stage is of some interest because of its association with growths in the liver of the rat.

Rausch (1946) found this parasite in the liver of four out of seventy muskrats (6%) in Iowa. Data which show the degree to which fifty-four animals from Montgomery County were parasitized are presented in Table 1. There was a slightly higher incidence of the parasite in adult (46%) than in subadult muskrats (33%). The greater number of cysts (16), however, occurred on the liver of one small, subadult female. A total of 19 (34%) out of 54 animals examined in 1950-51 carried the parasite. Each of six animals examined in 1952 harbored one or more of these cysts in its liver. Thus, twenty-five (42%) of the sixty muskrats examined during the two years, 1950-51 and 1951-52, from Stroubles Creek were parasitized by *Taenia taeniaformis*. In no case did an animal show any harmful effects from the parasites. It should be mentioned that the muskrat population on the creek in 1952 was extremely low as compared with previous years. It is questionable, however, whether the decrease may be attributed to parasites.

The limited amount of time spent on parasitological work during this investigation precluded the establishment of any host—intermediate host relationship in this case. The

[1]Release No. 52-5 of the Virginia Cooperative Wildlife Research Unit, Virginia Polytechnic Institute (College, Experiment Station and Extension Service), the Virginia Commission of Game and Inland Fisheries, the Wildlife Management Institute, and the Fish and Wildlife Service, cooperating.

TABLE 1.—FREQUENCY OF *Taenia taeniaformis* IN LIVERS OF 54 MUSKRATS FROM MONTGOMERY COUNTY, VIRGINIA, 1950–1951

	Number of muskrats	Number infected	Percentage infected	Range in number of parasites	Average number of cysts
Adults	11	5	45.5	4 – 12	4.8
Subadults	43	14	32.6	1 – 16	3.9
Totals	54	19	35.2	1 – 16	4.2
Males	30	11	36.7	1 – 9	3.5
Females	24	8	33.3	3 – 16	5.0
Totals	54	19	35.2	1 – 16	4.2

possibility that the continued persistence of the larval stage of the parasite may be due to predation on the muskrat by some carnivorous species has been considered. No evidence of such predation could be found. No minks are known to be present in the area. The red fox is the most abundant native predator on the area. Extensive food habits studies on the red fox have failed to reveal a single trace of muskrat in the diet. It is equally possible, however, that the larval stage is being carried through some other host-predator cycle such as the rodent-housecat. The muskrat could pick up the eggs after they had been released from the gravid proglottids of the worm passed in the feces of the carnivorous host. Several barn rats and rabbits from the same general area from which the muskrats came have been examined without encountering any parasitism of the livers by the larval forms of *Taenia taeniaformis*.

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FIG. 1. Liver of subadult female muskrat containing 16 cysts of *Taenia taeniaformis*

OBSERVATIONS INDICATING EGG-MOVING BY NESTING PHEASANTS

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During a pheasant nesting study, conducted by Pittman-Robertson personnel of the South Dakota Department of Game, Fish and Parks, some attempts of hen pheasants to save their eggs from destruction by flooding were noted by the writer on a study area near Mobridge, South Dakota.

Part of the study area was a small, intermittent marsh, about 40 acres in size, and nearly dry on May 25, 1947, when the first pheasant nest was discovered. This nest contained 10 eggs when found, and the number remained the same on succeeding visits. During the period June 3-6 approximately one inch of rain fell on the area. When the nest site was visited on June 6, it was noticed that the water level in the slough was considerably higher than before the rain, but the nest was not yet endangered. On June 10, the area received 1.25 inches of rain. The site was visited on the following day, and the nest was found to be covered with an inch of water. However, only four eggs remained in the nest. Three of these were pipped and all four contained embryos at the hatching stage, but all were dead. The other six eggs were resting in a new nest on a hummock of dry ground approximately three feet from the old nest. One of these eggs had hatched and the young bird was alive. The new nest, which must have been built within the space of a few hours, appeared as well-built as the original. The fate of the five remaining eggs in the new nest was not determined as circumstances did not permit a return to the site until June 14 when only broken pieces of egg shell remained.

Further search of the flooded portion of the slough on June 11 resulted in the discovery of another pheasant nest. This nest was also covered with water, and 12 eggs were present. Only one egg was in the nest; the others being scattered for a few feet in a shoreward direction from the nest. The water here was very shallow, just enough to wet the bottoms of the eggs, but no dry land was near. This observation indicated that the hen may have tried to move her eggs out of the water before abandoning them. The writer broke one egg and found no visible embryo present. The remaining 11 eggs were given to a farmer to set under a domestic hen. Eight of these subsequently hatched.

Incidents such as these probably occur too rarely to be of any importance in maintaining pheasant population levels, but they are of general interest, inasmuch as the writer knows of no other instances of pheasants attempting to move their eggs from flooded sites.

Accepted for publication November 14, 1952.

A NOTE ON PARTRIDGE TERMINOLOGY

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Uniformity in expression, especially in the use of common names of animals, must be aimed at in order to preserve continuation and enable mutual understanding.

The intention of this note is to point out how a new and superfluous name for a game bird may be creeping into the American wildlife literature, of little concern now when the species is not found in the United States (but where a close kin is present); the matter will be of more concern should the species become introduced, and in general because different names for the same birds always lead to confusion.

The bird referred to is the red-legged partridge, *Alectoris rufa*. This bird is a native of

France and southwestern Europe, from where it was introduced into, and well established in England. The bird's French name is perdrix rouge, meaning red partridge. In the English literature, the bird is described as and discussed under the name red-legged partridge (Kirkman & Jourdain, 1935; Vesey-Fitzgerald, 1946), or in daily use often as the French partridge.

This bird was unsuccessfully introduced into America in 1786 and 1896. Phillips (1928), describing these introductions, calls the bird by its original and proper English name: red-legged partridge.

In a recent reference to the work carried out on the wing moult of this bird by Bureau in France (1913), Petrides & Nestler (1943) call the bird red quail, and again Petrides (1951), giving a condensed table of Bureau's findings on the wing moult of the bird, calls it red quail.

As the red-legged partridge and the chukar partridge (the latter species, by the way, has also an old established English name, namely rock partridge) are very closely allied, of very similar appearance, size and biology, the moulting tables produced by Bureau can undoubtedly be used with advantage for the chukar until exact wing moult data has been collected for this bird in the United States, — and then they may be of value for comparison and substantiation, as Bureau's work is very detailed.

It would therefore seem desirable in future reference to this species to call it by its proper, old-established English name: the red-legged partridge because: 1) in France where the bird comes from, it is called perdrix (partridge); 2) it belongs to the genus *Alectoris*, the members of which in English all are called partridge (cf. chukar partridge in America); 3) the bird has an old established English name (dating back to about 1770) which should be recognized so much more as this name is currently in use in England where the species is common and often discussed in the wildlife literature; 4) the word quail invariably brings to mind the image of a small game bird, and as the red-legged partridge equals in size the chukar and is somewhat bigger than the Hungarian partridge such a preconceived illusion is misleading; 5) finally the quails are birds in well-defined genera with their characteristics, and there seems to be no justification for dumping in their midst a species from a different genus.

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Accepted for publication November 21, 1952.

CAPTIVE STRIPED SKUNK PRODUCES TWO LITTERS

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The wildlife student who sees a litter of very small skunks in late summer is faced with the question whether this female bred late in the spring and produced a single litter, or whether the litter might be a second one of the season.

Speaking of the number of litters of the skunk per year, D. E. Lantz (Economic value of North American skunks. U.S.D.A. Farmers' Bull. 587. 1914) indicates that "skunks breed usually but once a year." E. A. Nelson (Smaller mammals of North America. Nat. Geog. Mag. **33**: 477, 1918) says of *Mephitis mephitis*, "the single litter is born in April or May," and of *Spilogale putorius* he observes, "they have a single litter of two to six young each year." E. T. Seton (Lives of game animals, **2**: 353, 1928) speaks of a single breeding season, from Feb. 1 to March 31, in Connecticut, but states that old females "that are not mated on the first heat may experience a second rut four weeks later." He also says, "One of my western correspondents claims to have had two large litters in a single season." W. J. Hamilton Jr. (Winter activity of skunks. Ecol. **18**: 326–7, 1937) gives the breeding season of *Mephitis nigra* in central New York as early as mid-February and on into early March. In discussing the reproduction of the eastern skunk, H. M. Wight (Reproduction in the eastern skunk. Jour. Mamm. **12**: 42, 1931) mentions only one period of breeding, while several authors make no definite statement but imply production of a single litter.

This paper records that a captive skunk produced two litters during her first breeding season.

A pair of eastern striped skunks (*Mephitis nigra*) born in the spring of 1951, were obtained * in August of that year and a second male of approximately the same age was obtained a few months later. They were kept in separate cages for use in sex reaction studies.

* We are indebted to Mr. Ellsworth Jaeger of the Buffalo Museum of Science for the pair of skunks and to Rudolph Kopf for the second male. To these donors we acknowledge our appreciation and thanks.

On February 26, 1952, the female appeared nervous and more active than usual, and although her genitals showed no marked evidence of rut, her reactions indicated some sexual interest when she was placed with one of the males. At approximately ten months of age, she was coming into rut. Two days later she was more interested in the male, but not until March 2 was she sufficiently receptive to copulate. Within an hour and a half she bred twice to one male after which she was taken from the male's cage and returned to her own.

Between March 2 and 11, this female had access to the males on seven different days during which she completed eleven copulations. On March 11, she accepted a male once, but when he attempted a second copulation, she attacked him viciously, lacerating one of his front paws. Thereafter she was non-receptive and would attack a male whenever placed with one.

On May 16, seventy-five days after her first copulation and sixty-six days after the last copulation of the first breeding period, she gave birth to four strong active kittens, two males and two females. To avoid exciting the mother and causing possible injury to the young, they were left undisturbed for forty-eight hours. At the end of this time all of the young were found dead, but they bore no marks of injury. The female showed no evidence of lactation, and this undoubtedly contributed to the death of the young.

On the third day after parturition, a male was placed in the female's cage. She immediately attacked him vigorously with her teeth and claws driving him into a corner of the cage where he remained until removed. Five days after parturition, the male was again introduced, but this time instead of attacking him, the female showed signs of sexual interest.

Nine days after parturition, on May 25, a week after the young had died, she was sufficiently advanced in her second rut period to breed to each of two males, after which she was returned to her cage. The next day, she accepted one male once and a second male

three times, but when the second male attempted coitus a fourth time, she attacked him viciously. After a short, violent, noisy fight, the female dominated the male and drove him into a corner where he tried actively to protect himself from her frequent vigorous efforts to seize and bite his feet and lower legs as she had previously done at the end of her first breeding period. Thereafter she would attack a male whenever placed with one.

On July 28, sixty-four days after the first copulation of her second breeding period of the season, she gave birth to three vigorous kittens, one female and two males, which she raised.

Comparing her first and her second breeding dates, it is noteworthy that the first period of copulations covered ten days in early March, while the second period of sexual receptivity and copulations covered only two days in late May. Since the first copulations extended over a period of ten days, her first gestation period must lie within the range of sixty-six to seventy-five days, as figured from the last or the first coitus. The second gestation period was sixty-four days from the first copulation or sixty-three days from the last copulation of the second breeding period. The first litter numbered four, the second contained three. Lactation did not accompany the first parturition but did accompany the second. Although the female's first parturition was followed shortly by a second period of rut, no signs of heat followed the birth of the second litter, and the female's reactions thereafter were quite antagonistic to any male placed with her. Since there was no lactation following the first parturition, the inhibitory effects of lactation on the next sexual cycle did not occur, and she came into rut promptly.

This case demonstrates that a skunk losing her litter early may experience another period of rut, a second copulatory period, and may have a second litter late the same season.

Accepted for publication November 24, 1952.

A COLLAPSIBLE QUAIL TRAP[1]

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A light-weight, collapsible quail trap, quickly set up or taken down and easily transported in a passenger car or carried in the field, was desired for the bob-white (*Colinus v. virginianus*) banding program on the Decatur County Quail Research Area in southern Iowa during the winter of 1951–1952. As a consequence, a quail trap was constructed similar to the "New York" game bird trap (H. L. Kutz, An improved game bird trap. Jour. Wildl. Mgt. 9: 35–38, 1945).

The body of the trap, 30 inches square and 10 inches high when erect, consisted of two 10″ x 30″ sections and four 10″ x 14″ sections of half-inch mesh hardware cloth attached to frames of 8-gauge galvanized wire (Fig. 1). The hardware cloth was fastened to the frames by stove-pipe wire or by bending the projecting wires of the hardware cloth around the frame. An opening six inches high and eight inches wide was left for an entranceway in each of the larger sections and was reinforced with 12-gauge galvanized wire. The six sections were hinged together with two No. 1 pig rings at each joint. The top was one-inch mesh (bar measure) seine of No. 18 cotton thread laced to the sides with cotton cord.

Two half-funnel entrances were constructed separately to be attached to the trap when it was erected. They were made of half-inch mesh hardware cloth on a frame of 12-gauge, galvanized wire. The entrances, six inches high and eight inches wide at the mouth, and five inches long, were tapered to an arc four inches

[1] Journal Paper No. J-2220, of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 494. U. S. Fish and Wildlife Service, Iowa State College, Iowa State Conservation Commission, and Wildlife Management Institute cooperating. The research was conducted under the direction of Drs. E. L. Kozicky and G. O. Hendrickson.

wide and four inches high (Fig. 1). "Feeler wires," three-inch extensions of the wire of the hardware cloth, extended beyond this arc.

The wire parts of the traps and the half-funnel entrances were painted a drab greenish-brown color. The cost of materials was approximately $2.05 per trap.

For stakes, two No. 60 common nails driven near the joints on opposite ends of a trap prevented it from collapsing when the ground was frozen. Larger stakes were necessary when the ground was not frozen. The half-funnel entrances were fastened over the entranceways with two loops of stove-pipe wire. Therefore, they were quickly and easily attached or detached. Birds were removed or bait was introduced through an entranceway after the half-funnel entrance had been detached and pushed to one side.

When birds were trapped, a cloth cover was thrown over the trap, which reduced the efforts of the quail to escape. Each quail was caught and removed individually by pressing it to the ground with one hand over its back. A receiving or banding cage for removing the quail would have facilitated banding (M. C. Reeves, Mechanical aids useful in studying bobwhite quail. Jour. Wildl. Mgt. **16**: 316–319, 1952).

The trap collapses into a 30″ x 10″ x 1″ bundle, weighing about four pounds. The half-funnel entrances are open on both ends and bottom so that they may be stacked inside each other (Fig. 2). They are easily stored and transported.

The half-funnel entrances are constructed similarly to the large semi-conical type which Reeves (*ibid.*) found to be more effective than smaller, tunnel-like entrances used in the "Stoddard" standard trap (H. L. Stoddard, The bobwhite quail. Scribners. N. Y. 559 pp. 1931). By using two entrances instead of one, the quail are given access to the trap from both sides. The net serves both as a buffer and as a top for the trap and the flexible sides of the

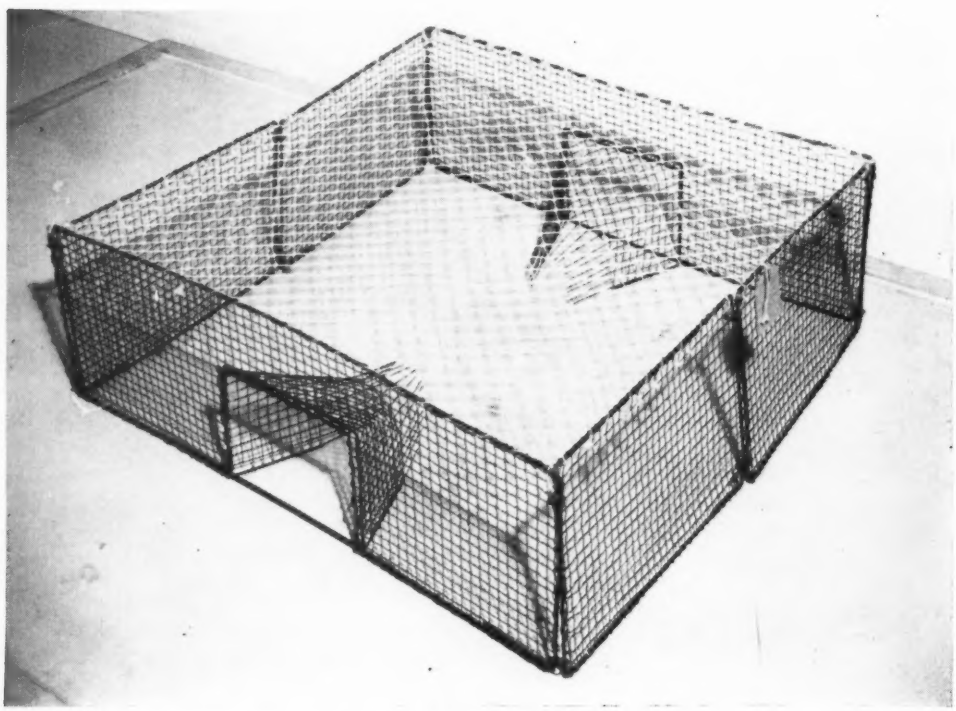

FIG. 1. The quail trap erected.

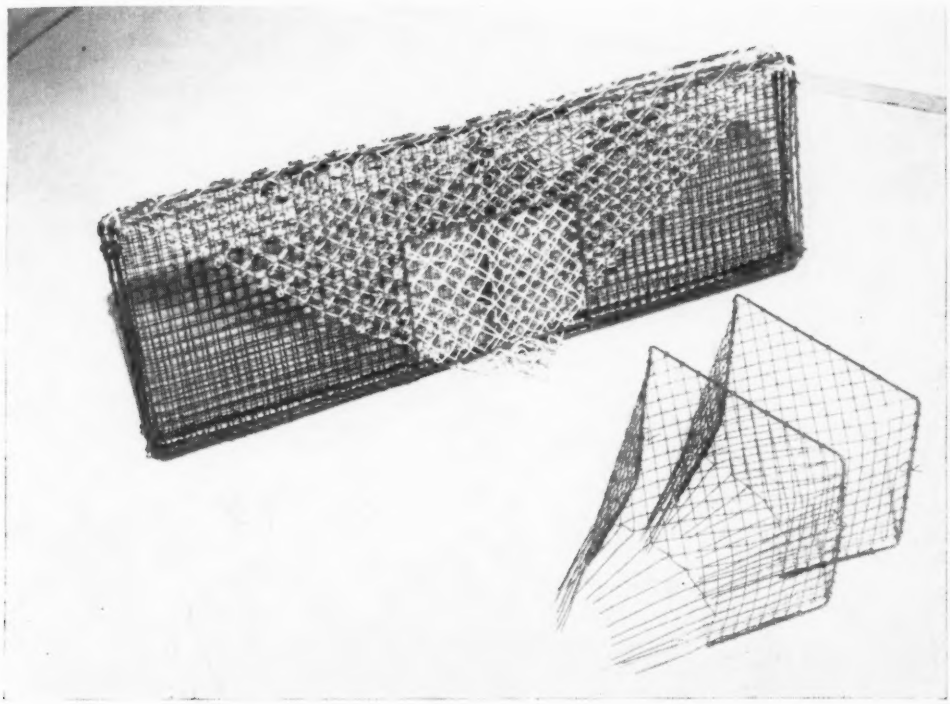

FIG. 2. The quail trap collapsed, showing stacked funnels.

trap further buffer plunges of captive birds. The method of collapsing eliminates the taking apart of sections of the trap, which is difficult and time-consuming in cold weather.

Accepted for publication, December 29, 1952.

WEIGHTS OF RUFFED GROUSE IN WEST VIRGINIA

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Checking stations on West Virginia's state forests offered technicians the opportunity to weigh 168 ruffed grouse during the seasons of 1949, 1950 and 1951. The results indicate that ruffed grouse in West Virginia are heavier than those recorded by G. Bump, R. W. Darrow, F. C. Edminster and W. F. Crissey (The ruffed grouse. N. Y. State Cons. Dept. Albany. 915 pp. 1947) in New York (Table 1).

Sex and age classes for West Virginia grouse were based on the techniques developed by G. A. Ammann (Results of the 1945 and 1946 fall grouse surveys. Mich. Dept. Cons. Info. Circ. 42. 1947). One change was made. The two middle tail feathers were pulled and their total length was measured in millimeters. The analysis of the West Virginia sample was based on the following measurements:

1. Grouse with pulled middle tail feathers measuring 155 millimeters and under were classified as females.

2. Grouse with pulled middle tail feathers measuring 161 millimeters and over were recorded as males.

TABLE 1.—WEIGHTS OF RUFFED GROUSE *
Average weight in grams

	Adult Male	Adult Female	Juvenile Male	Juvenile Female
	West Virginia—Hans G. Uhlig			
Nov., 1949	616 (13)	591 (3)	644 (14)	543 (13)
Oct., 1950	684 (13)	561 (1)	644 (11)	564 (4)
Nov., 1950	698 (10)	587 (2)	634 (5)	557 (9)
Oct., 1951	670 (20)	565 (5)	619 (25)	543 (20)
	New York—Bump *et. al.* 1947.			
Oct., 1947	635 (7)	573 (8)	594 (13)	488 (17)
Nov., 1947	654 (13)	577 (6)	597 (10)	524 (6)

* Sample size in parenthesis.

3. Grouse with tail measurements falling in the 156 to 160 millimeter class were classified as undetermined.

Few specimens were discarded by adding the undetermined class and it is believed that this class aided in eliminating overlapping of classes to some extent.

Accepted for publication, December 18, 1952.

EDITORIAL NOTES

With the publication of the April issue, Dr. Kenneth D. Carlander completed a period of efficient service as Associate Editor for papers on fisheries subjects. In extending thanks to him on behalf of the Society, it should be pointed out that the work of the retiring editors, Drs. Swanson and Carlander, does not cease abruptly, but continues to benefit the present, and even succeeding issues.

The President has appointed, as new Associate Editors, Dr. Carlton M. Herman, for terrestrial papers, and Dr. Louis A. Krumholz, for fisheries papers. Their duties will include the responsibility of advising with regard to acceptability of manuscripts for publication, various other more onerous tasks of preparing articles for publication, and, in general, working with the Editor for a Journal of interest and value to Society members. In a field as varied as ours, this is not a simple job. The Editor is appreciative of the experience and ability of our new Associate Editors.

Members will be glad to hear that the film "Bobwhite Throughout the Year", which is reviewed on page 371, has been awarded the CONI Grand Medal in the International Sports Film Festival at Cortina d'Ampezzo, Italy.